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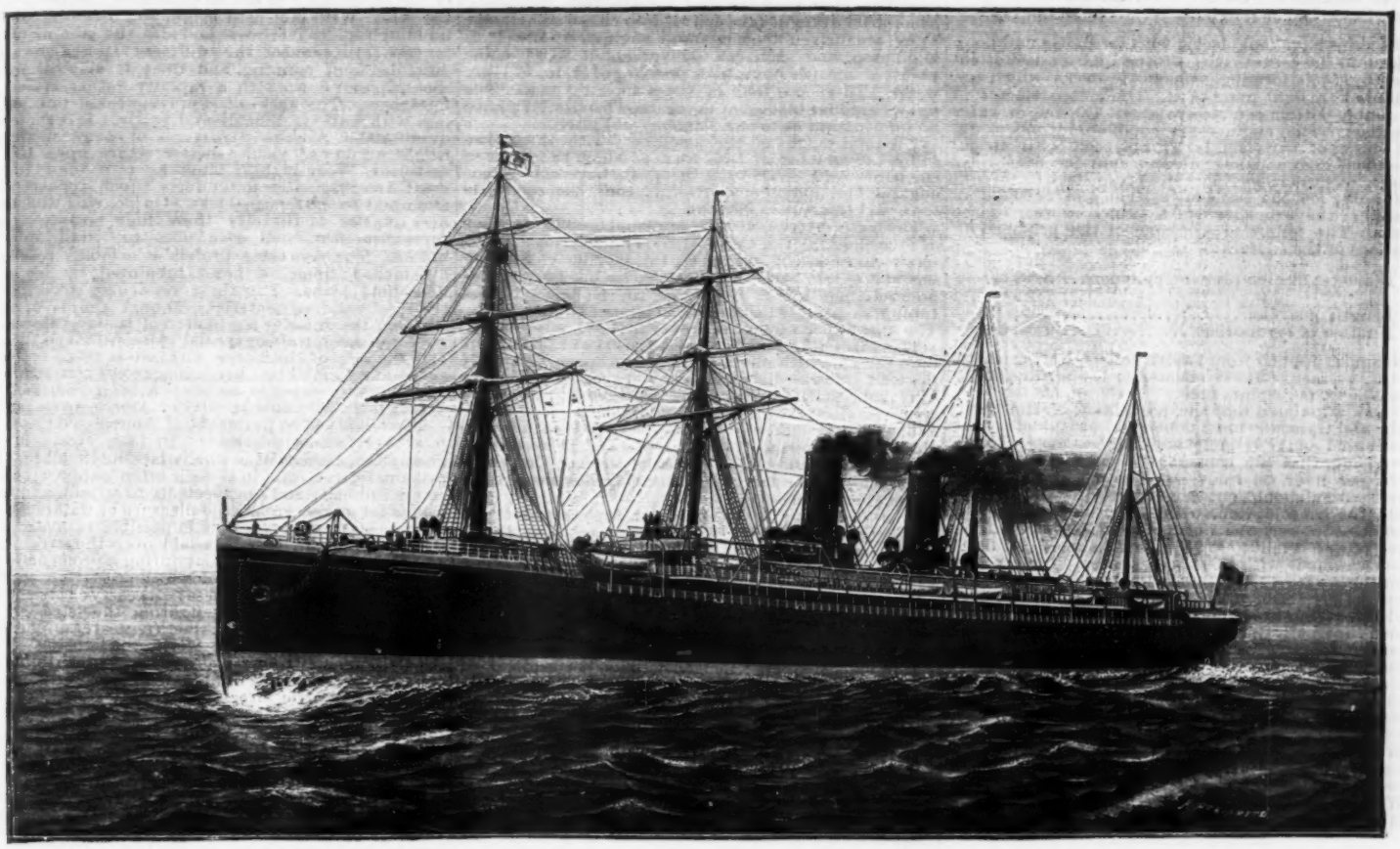
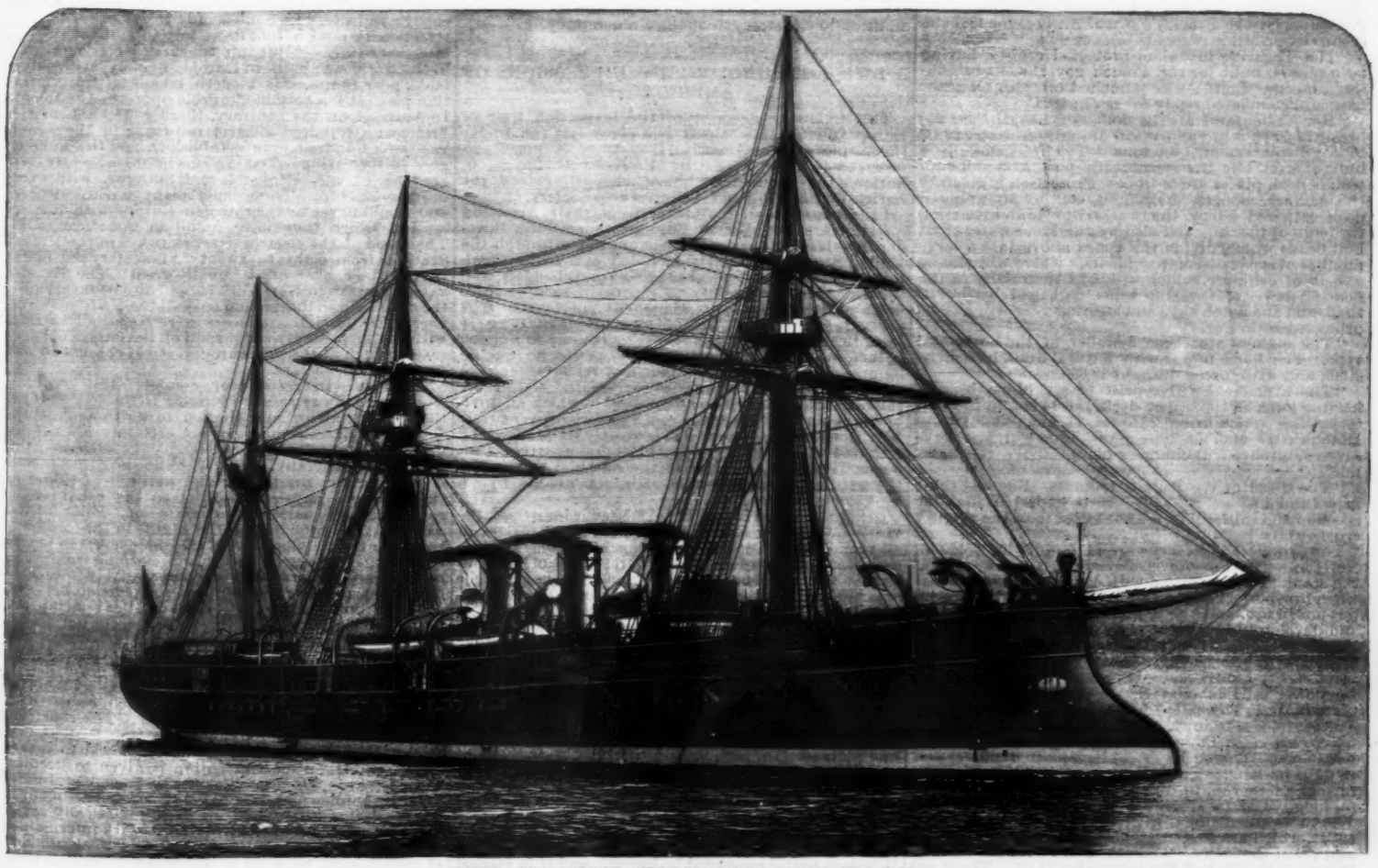


THE FRENCH ATLANTIC PASSENGER STEAMER BOURGOGNE.



THE FRENCH WAR SHIP LE TAGE.

THE FRENCH STEAMER BOURGOGNE.

WE publish a view of another of the favorite Atlantic liners—the Bourgogne—belonging to the Compagnie Generale Transatlantique, and which, with her sister ship, the Gascogne, has been in continuous service since 1886. Both these ships were built by the Forges et Chantiers de la Mediterranée at their La Seyne Works, to the order of the Transatlantic Company, who supplied the Forges et Chantiers with the general conditions to be fulfilled, the detailed plans having been prepared by the Forges et Chantiers' chief engineers, MM. Orsel and Lagane. The principal particulars of these ships are as follows:

Length between perpendiculars...	493 ft.
Beam.....	52 ft. 2 in.
Mean draught, loaded.....	24 ft.
Displacement.....	9925 tons.
Gross tonnage.....	7972 "
Net tonnage	5000 "
Indicated horse power.....	9800

The ships have four decks, with forecastle and poop decks, and the central part of the quarter deck is inclosed by roofs forming promenade decks, which are connected by light gangways. The compartments in the double bottom can receive about 750 tons of water as ballast. The engines are compound condensing, and consist of three similar groups, each with an independent high and low pressure cylinder, the former being above the latter. The shaft is of steel, the crankshaft being on the built-up system and 22·60 in. in diameter; the propeller has a steel boss with bronze blades. The following are some of the principal dimensions of the engines:

Diameter of high pressure cylinders...	38·65 in.
" low " " ...	78·86 "
Length of stroke	69·98 "
Number of revolutions.....	52 to 62.

Steam is supplied from twelve boilers, having a total heating surface of 24,918 square ft.; the working pressure is 85 lb. per square inch.

It was stipulated that the acceptance of the Bourgogne and Gascogne must depend on obtaining a minimum speed of 17·5 knots and 8,000 indicated horse power, and that the consumption of coal per horse power per hour, on a developed power of about 6,100 horse power, should not exceed 1·98 lb. During the trials, the consumption, with a developed power of 6,100 horse power, was only 1·826 lb., and with 7,200 horse power it fell to 1·694 lb., and a speed of 19·035 knots was made with 9,800 horse power. The contract conditions were therefore largely exceeded, and since the ships have been in service many passages have been made averaging 18·50 knots per hour. It should be mentioned that both the Gascogne and the Bourgogne are intended to serve as transports, or even as cruisers, should the occasion arise, and for this purpose the ships are constructed so as to mount seven guns of 5·51 in. caliber. As will be seen from the engraving, the ships have four masts, two of which carry square sails; they are luxuriously fitted, and have earned a high reputation for regularity and comfort; the accommodation on each boat includes space for 221 first class passengers, 72 second class, and 906 steerage.

We are indebted to *Engineering* for the above particulars and for the engraving.

THE FRENCH WAR SHIP LE TAGE.

OUR engraving, for which we are indebted to *The Engineer*, illustrates one of the recent additions to the French navy. In Brassey's *Naval Annual* for 1887 she is thus described:

"The Tage is a first-class protected cruiser, having twin screws, built for the French government by contract, on the Loire; was launched on 28th October, 1886, and completed ready for sea in 1888.

"Her dimensions are as follows: Length, 390 ft.; breadth, 50 ft. 8 in.; and mean draught of water 22 ft. 10 in.; displacement, 7,045 tons. The hull generally is built of steel, but the stern, stern post, keel and protective deck plates are of iron. Protection is given to the engines, boilers, magazines, etc., by an armored deck situated below the water line and extending throughout the ship, and also by numerous water-tight bulkheads which divide the space above into a large number of separate compartments. There will also be a belt of cellulose, which will add materially to the floating power of the ship when damaged by shot or shell, and the hatchways and steering gear will also be protected by armor.

"The engines are three cylinder, of the horizontal type. The horse power with natural draught will be 8,115, and with forced draught 12,000.

"The armament will consist of six 16 cm. breech-loading guns on the upper deck, ten 14 cm. in the battery, three quick-firing guns of 47 mm., and twelve Hotchkiss 37 mm. machine guns. She will also have seven Whitehead dischargers placed above the water line.

"The speed of the Tage is 19 knots. She has three masts and a spread of sails. It is expected that the speed of the ship will be a knot faster than the English cruisers now building."

The cylinders of Le Tage are 43 in. + 68 in. + 100 in. × 47½ in. The low pressure cylinders lie forward, and the crank shafts are fitted with coupling boxes, so that when low powers suffice the low pressure cylinders are put out of use, and the engines then work compound and develop 1,970 horse power, making fifty-two revolutions per minute. With natural draught and all the cylinders in use the power is 8,950, the revolutions being eighty-nine per minute; and with forced draught the power is 11,370, and the revolutions ninety-seven per minute. The safety valves are loaded to 150 lb. The valve gear is Joy's. Steam is supplied by twelve boilers arranged in groups of four in water-tight compartments. The shells are 14 ft. 3 in. in diameter and 10 ft. 9½ in. long. There are in each boiler three Fox's furnaces, 3 ft. 7 in. in diameter. The grates are 7 ft. 7 in. long. The total grate surface is 930 square feet. The tubes are of brass, with the exception of the stay tubes, which are of iron. There are 3,816 of the former and 792 of the latter. The diameter inside of the brass tubes is 3 in., that of the iron tubes 2¾ in. There are three chimneys, one to each group of boilers. They are 8 ft. 3 in. in diameter.

There is one surface condenser in each engine room. Each contains 5,633 tubes, 0·7 in. diameter and 9 ft. 8 in. long. The total surface is 10,097 square feet, or about 1·75 square feet per horse power with forced draught, 2 square feet with natural draught, and 8 square feet when working compound.

The pumps are worked by distinct inverted cylinder engines. There are two air pumps in each engine room, 28¾ in. diameter and 19¾ in. stroke. They are single acting, and make 81, 138, and 150 double strokes per minute, according as the engines are working compound, with natural, and with forced draught. There is one centrifugal circulating pump in each engine room, making 100, 147, and 160 revolutions per minute. The disk is 48 in. diameter. There are two feed pumps, single acting, in each engine room, 6¾ in. diameter and 19 in. stroke. The main crank shafts are hollow, and 15¾ in. diameter, the hole being 7 in. in diameter. The connecting rods are four cranks long. The piston rods are 6¾ in. diameter. The cylinders are jacketed all over the high pressure and intermediate cylinders. The forced draught fans deliver into closed stokeholds. They are driven by compound engines, by Elwell & Middleton, and each can deliver about 70,000 cubic yards of air per hour, at a pressure of 1 in. to 1½ in. water. There are four of these blowing fans. The screws are four bladed, of manganese bronze. We have no information as to the diameter and pitch.

The total weight of the machinery with the boilers full is 1,685 tonnes, or 1,659 tons, of which the water in the boiler weighs 250 tons, the grate bars 30 tons, the engines 540 tons, the shafting 72 tons, the screws 16 tons, and the boilers 459 tons.

The main bearing brasses are composed of an alloy of 84 copper, 16 tin, and 2 zinc. The bearings in the screw alleys are of copper 86, tin 14, zinc 2. Stuffing box glands, etc., are of copper 88, tin 12, zinc 2. The boiler fittings are of copper 90, tin 10, zinc 2. Brass tubing, so called, when used, is of copper 94, tin 6, zinc 2. The anti-friction metal is copper 4, tin 96, antimony 8.

The valve gear is so arranged that the cut-off in the high pressure cylinder is variable between 25 and 74 per cent., intermediate cylinder between 25 and 70 per cent, and in the low pressure between 37 and 79 per cent.

The ship is lighted by electricity. There are two Mangin projectors 2 ft. in diameter, and there are 300 incandescent lights in each compartment. Current is supplied by three large Gramme dynamos arranged in the engine rooms.

Compressed air is supplied for the torpedoes by Brotherhood machines.

The contract price was 8,750,000f., or £348,000. Of this the hull cost £180,000; armor, etc., £26,200; the engines, £110,000; the boilers and the appurtenances, £42,840.

The estimated displacement of the ship, with all her weights on board, and a mean draught of 23 ft. 9 in., is 7,000 tons. It is noteworthy that she carries 900 tons of coal.

Her dimensions are: Length between perpendiculars, 389 ft. 9 in.; beam at the water line, 53 ft. 6 in.; depth, 35 ft. 11 in.

According to contract, she was to maintain a mean speed of nineteen knots for six hours, while burning not more than 33 lb. of coal per square foot of grate per hour. For each $\frac{1}{10}$ of knot in excess the contractors were to receive 10,000f. premium; for each $\frac{1}{10}$ of knot under they were to forfeit 10,000f. A second trial of two hours was then to be made, the furnaces being pushed to the utmost. No penalties or premiums attached to this trial, which was intended solely to ascertain what was the utmost that could be got out of the engines. The ship has been very carefully finished throughout. She is a very fine vessel, and an important addition to the strength of the French navy.

A SWISS TECHNOLOGIST'S IMPRESSIONS OF AMERICA.

THE following account of the inspection tour of European engineers, which took place last fall under the auspices of the American Society of Mining Engineers, was lately read by Professor G. Lunge, of Zurich, the eminent technical chemist, before the Zurich Engineering and Architectural Society.

In response to an invitation from their American colleagues, a number of European metallurgists undertook last October an inspection tour through the United States. The party included also many architects, civil and mechanical engineers and chemists, and it was therefore possible to secure in each of these fields the judgment of competent specialists. The party numbered in all 540 persons, of whom 400 were from England. Of the noted English metallurgists, in fact, only one was lacking—Bessemer, who was no longer willing to risk the fatigue and inconvenience of a sea voyage. France was not represented, since there exists in that country no association to which an invitation could be addressed. From Switzerland went Herr Von Moos and the writer. It is greatly to be regretted that one of our most renowned representatives, Professor Tetmayer, director of the national station for the testing of building materials, was unable to accept the invitation.

General Impressions.—The Americans impressed the visitors with their facility in handling great masses in all branches of technology, in machine construction, architecture, transportation and treatment of raw materials. In their operations economy of hand labor appeared everywhere especially striking. This is partly to be explained by the fact that the cost of labor is generally very high. There can be no doubt, however, that the Americans understand, as do no other people, the art of applying machinery to the fullest extent possible, and of deriving from machinery all the advantage which it is capable of yielding. In spite of this, and of the often remarkable ingenuity shown in the arrangement and design of apparatus, the existence of a special American *genius* can not be acknowledged. In fact, in the careful working out of details America has in many lines remained behind Europe. It should, however, be remembered that in America it is impossible to expend for studies anything like the amount of time and money which in Europe would be considered necessary for the success of the undertaking. Form, and often also *economy*, are therefore better preserved in Europe, and if in respect of magnitude our continent stands behind the great republic, this is simply due to the fact that the extension, resources and needs of the United States have of necessity called into being the gigantic element in all branches of technology. To mention one instance only: For several years there have been built in the United States, on an average, 12,000 kilometers of railway per year. According to the view of one of the leading mine owners, this number will be exceeded during the next few years. "Give us the same problems under the same conditions and we will solve them as well as the Americans," said the European engineers.

Architecture.—The stranger is first struck with the gigantic dimensions of many buildings in the great cities, especially in respect of height; 16 stories are of frequent occurrence, and buildings of even 28 stories are projected. These enormously high structures require massive and costly foundations; therefore care is taken to make the whole edifice as light as possible by building it in the form of an iron framework, with a thin outer shell of stone or terra cotta; by this means fire proof qualities are also secured. The height of the buildings is of course determined by the cost of the site. With increased height the first cost of the building rapidly increases, and also the cost of maintenance; to connect the different stories elevators must be kept running, and these, it may be noted, shoot up and down with a rapidity rather trying to foreigners. The task of supplying these tall buildings with water is difficult and costly. It is therefore questionable whether structures of more moderate height would not yield a better return upon the investment. Very high buildings are to be found in the great American cities in numbers which appear quite abnormal to European ideas. On leaving the business quarter of the city these high, massive structures disappear, and give place to simple wooden houses. The American prefers as a family residence a detached home, a *house*, inhabited by his own household alone. For these residences wood is still the chief building material. Though simple in their exterior, the interior equipment of these houses is elegant and comfortable; special pains are taken to provide the lady of the house with all possible conveniences, and to facilitate her management of the household in every possible manner—a consequence of the almost incredible unreliability of American servants.

Streets, etc.—The pavement of American cities is almost everywhere miserable. In fact, except in the great cities, pavement is wholly lacking in all but the principal streets, and in these it often happens that it comes suddenly and unexpectedly to an end, and from this point on one enjoys the pleasure of walking knee-deep in mud, wherever it is impossible to avail one's self of the plank crossings laid over the street here and there. On looking about during a promenade one sees a multitude of posts, of which it is rare to find one standing vertically. These posts carry electric wires, many of which serve for lighting the streets. Although electricity finds in America greater application than anywhere else in the world, the lighting of the streets is generally very poor. Except in certain open squares, and in streets illuminated by brightly lighted stores, the electric street lighting in New York and Philadelphia is no better than the gas lighting in Zurich, which is certainly not saying much for it! An exception is to be found in Chicago, which of all American cities visited by the writer leaves in this repect least to be desired.

The most striking and surprising results are, however, to be seen in means of transit. Horse cars, cable railways or electric railways, singly or side by side, are to be found almost everywhere. Pittsburg, for example, which a hundred years ago contained 400 inhabitants and now has 400,000, possesses horse cars, two cable roads of 36 kilometers total length, and also an electric railway. La Salle is only thirty years old, has streets with mud a foot deep, but in spite of this an electric railway. Although the first electric railway in the world was built in Europe, namely, at Lichterfelde, near Berlin, this modern means of transportation plays still a very modest role upon the Continent. In America, on the contrary, there were built in the first year a hundred electric railways; in the second year two hundred were established, and the number goes on increasing. The systems most frequently used are the Thomson-Houston and Sprague, with overhead conductors. These cause many inconveniences, and would never be tolerated in Europe with the extension which they have found in American cities. The speed of the electric street railways in the United States is from eight to twenty kilometers per hour; that of the cable roads is equally great. The five elevated railways in New York should also be mentioned; they are bold in design and splendid in their performance. The foreign engineers were especially struck with the surprisingly small radii of the curves of these roads, which at the turns around street corners do not exceed fifteen meters.

Railways.—In respect of comfort the ordinary American railway cars are inferior to those of Europe, the seat is narrow and limited in width and depth. The parlor and sleeping cars are certainly beautifully fitted up, and offer the traveler plenty of room; the seats have generally, however, upholstered arms and no rest for the head. For the privilege of riding in these cars one pays—in addition to the usual fare, a sum which is remarkably moderate—one dollar for the day and two dollars for the night in the ordinary trains, and five dollars for twenty-four hours in trains consisting entirely of parlor and sleeping cars. The regular railway fares are also comparatively low. This may be partly the result of great competition between different lines. It should, however, be remembered that the original cost of the railways was not great, and that the companies often received immense grants of territory. Although these were at first by no means model establishments, there exist nevertheless, at the present day, railways in the eastern and northeastern part of the United States which compare favorably with the best European lines. The construction of the track and foundation is as careful as it is solid; all possible appliances are employed to insure safety, and the utmost attention is given to keeping the roads in repair. For this purpose the apparatus devised by Dudley is especially valuable; in passing over the road] this instrument draws automatically seven different curves, which give all necessary information in regard to the condition of the rails. The amount of rolling stock required by American railways is indicated by the following statistics: At the Altoona locomotive works, in 1889, 150 locomotives were built

and 600 repaired; in 1891 the first number will reach 250; in the Pullman factories there are built every week three sleeping coaches, ten passenger cars and 240 freight cars, in the construction of which 1,500 tons of iron are employed.

Waterways.—These form one of America's greatest advantages. Thousands of kilometers may be covered along these without the necessity of unloading. For example, from Pittsburg, located at the junction of the Alleghany and Monongahela Rivers, coal is sent along the Ohio and Mississippi Rivers to New Orleans, a distance of 3,200 kilometers, at a cost of less than one-third of a cent per ton per kilometer. While Pittsburg is the center of export for coal, Marquette, on Lake Superior, is the center of the iron ore trade. From the latter place to Chicago the distance is 1,000 kilometers, but the freight on the great lake steamers does not exceed that for transport by lighters in England over twenty kilometers of distance.

In speaking of the employment of water power for technical purposes, the falls of Niagara naturally come first to mind. This fall consists of the upper and lower rapids, with a total descent of fifty meters, and the vertical fall lying between these two rapids, also fifty meters in height. The latter consists of two separate parts—the American Fall with a width of 300 meters, and the Horseshoe Fall with a width of 670 meters, Goat Island lying between these two parts. The bed of the Niagara River narrows below the falls to a width at the whirlpool of 120 meters. The total flow of water is estimated at 100 million cubic meters per hour (28,000 cubic meters per second). Of the 4¼ million horse power which this flow represents, only about 2,000 are utilized.

A company now proposes to obtain 120,000 horse power from the falls, in the following manner: 1·6 kilometers above the American Fall a canal is to be cut, from which at several points shafts are to descend to a tunnel lying 48 meters below the surface, and terminating in the bed of the river below the falls. In these shafts turbines are to be placed, which will discharge into the tunnel. It was formerly intended, as is well known, to convey the power of Niagara to great distances by transforming it into electricity. The company mentioned above has not pursued this plan, but has secured large amounts of land in the immediate neighborhood of the falls, and proposes to erect factories or to sell or rent the land to manufacturers under contract that the power required shall be furnished by the company.

Metallurgy.—Scarcely any other country possesses ores and fuels in such quantity and of such excellent quality as America. These are also, in part, very favorably located. Pittsburg, for example, lies in the center of a coal field covering an area of 36,000 square kilometers,* which produces annually thirteen million tons of coal. In addition to this advantage, Pittsburg is also the center of a great petroleum region, which yielded twenty-two million barrels in 1889. The oil wells reach a depth of 1,000 meters, and certain pipe lines leading to the city are 500 kilometers in length, and provided with pumping stations at intervals of fifty kilometers. These pipe lines are from five to twenty cm. in diameter, and consist of drawn wrought iron pipes which are simply screwed together without packing.

In spite of the high pressure which the pipes have to sustain, this arrangement is said to be in all respects satisfactory. In boring wells the Americans are certainly unexcelled. Most ingenious devices are employed in recovering broken boring tools and cutting screw threads at any depth. One well, for instance, became filled up at a depth of 600 meters; not only were the tools extracted, but a bent pipe was partly cut out and partly straightened, a screw cut, and the boring continued. The well was finally successful.

The coal found in the neighborhood of Pittsburg is bituminous. For this reason it was formerly impossible for the inhabitants to see the sun. Now this happiness may be enjoyed in Pittsburg as well as elsewhere, by virtue of the discovery of another of Nature's valuable gifts—natural gas. This consists chiefly of marsh gas, and burns with a bright but not smoky flame. Seven hundred and seventy cubic meters of the gas are considered equal in heating power to a ton of coal. The present consumption of gas is over three billion cubic meters, equivalent to five million tons of coal, valued at $6,500,000.

There are some wells in the city, others lie at distances up to 100 kilometers, and are connected with the city by pipe lines, some of which reach a diameter of 90 cm. (3 ft.) The total length of pipe lines for natural gas exceeds 1,800 kilometers. It is a great question how long the supply of gas will hold out. It is true that no diminution in the yield has yet been observed. The consumption is, however, steadily increasing, and it has been thought prudent to limit the employment of natural gas by restricting its use to certain purposes.

The chief deposits of iron ore, as already stated, are found on Lake Superior. These ores lie so near the surface that they are still chiefly mined in open workings. Ores of 45 per cent. are rejected as too poor for use. The average richness is 63 per cent., though ores of 65 per cent. are found. In this region occur perfectly pure hematites and magnetites, so free from phosphorus that the acid process of steel manufacture may be employed with perfect success, and this process is met with almost exclusively in the United States. The high percentage of iron explains the possibility of transporting these ores to Pittsburg, a distance of 1,600 kilometers, 1,000 km. by water and 600 km. by rail. If the magnetite ores are accompaned by gangue, electro-magnetic concentration is frequently employed. The ore is passed through a magnetic field, and the non-magnetic refuse driven away by a blast of air. In spite of the fact that large plants of this kind exist, it is certain that the process will not be generally introduced.

The total production of iron ore in the Lake Superior region in 1890 was 7,200,000 tons. The chief point of shipment is Marquette, where there are four great wharves, with a total length of 1,500 meters, which offer 744 loading places and can accommodate 70,000 tons of ore. The arrangement for loading consists of great hoppers, into which the cars discharge as they come from the mine; from these the ore is conveyed by shoots directly into the vessels.

Copper ores are also found on Lake Superior. The best known mines are the Tamarack and the Calumet and Hecla, of which the latter is the larger. The copper occurs native and almost chemically pure, in masses up to several hundred tons in weight; the larger part is, however, found in crystalline form, penetrating various rocks, forming two to three per cent. of the weight of the ore. Rock containing one half per cent. may be profitably worked. The mines are very deep, certain shafts reaching a depth of 1,130 meters; nevertheless, they are quite cool, a phenomenon that has not yet been explained. The engines employed in the mines are of immense size; the Calumet and Hecla has engines of a total horse power of 37,500, one of which, of 4,700 h. h., weighs 428 tons and works at a pressure of 9·4 atmospheres. The ores are treated by pulverizing in stamp mills and concentrating the fine material; the concentrates contain about thirty per cent. of copper. In 1889, the several mines produced 2,000,000 tons of ore, corresponding to 34,000 tons of copper. The total production of the mines, up to 1889, has amounted to 507,000 tons of metal. The profits of the enterprise are very great. The Calumet and Hecla mines, the director and chief manager of which is a Swiss (Prof. Agassiz, of Boston, son of the scientist Agassiz, of Neuenburg), with a capital of three millions, has paid in twenty years dividends to the amount of 33,350,000 dollars; while the other mines have paid 11,300,000 dollars more.

Nickel ores occur at Sudbury, Canada, in surprising abundance, containing as high as thirty per cent. of metal, so that any desired quantity of nickel can be obtained from this source. There seems to be prospects of a new application of this metal, in addition to the many uses to which it has heretofore been applied; in America *nickel steel* is now being experimentally made, an alloy which is said to display a number of remarkable qualities.

Aluminum is made in Pittsburg by the Hall electrolytic process, but only in limited quantity (about 150 kilogrammes per day). The projected great extension of this industry is thus far only on paper, and the establishment in Pittsburg is not to be compared with that in Neuhausen.

The lead, silver and gold regions lie at such distances that they could not be visited by our party.

In regard to the treatment of ores, I shall speak only of those of iron. The general impression made by the American iron works is most striking. They are impressive in their magnitude and dazzling in their rate of production, but in no sense original except in the arrangement of details. All the works are built on one plan, and one finds everywhere the same types of furnaces and engines. The general design resembles the English; but while one blast furnace in England yields on the average 80 tons daily, and in France and Germany 120 tons, there are to be seen in Pittsburg blast furnaces which produce 400 tons of pig iron per day, with a consumption of coke of only 84 per cent. At first not more than 80 tons were obtained, then the yield was considerably increased, but with a corresponding increase in the amount of fuel required. At last means were found to reduce the consumption of coke and increase the output to the figure stated above. Several causes probably unite to produce this result; the chief factor is, however, the wonderful quality of the ore. In working with ores of 62 per cent., the conditions are very different from those in the case of 40 per cent. ores, like those used on the Rhine, or 30 per cent. ores, as in Silesia. This comparison does not, indeed, sufficiently explain the difference in production, but, in spite of this, the explanation of the facts is still to be found in the ores employed.

The case of the Bessemer steel industry is similar. For this process extraordinarily pure pig iron is available, seldom containing more than one per cent. of silicon; the proportion of carbon is also low. While at first only twenty-four heats per day could be made, then thirty-six, it is now found possible to make 118 heats daily, or one every twelve minutes. Since the silicon acts as the fuel, but is present only in small quantity, it is necessary, in order that the product shall not be too costly, to work as rapidly as possible, in order to lose less heat by radiation. As an example, one works produces daily, with two converters, 852 tons of steel, or 320,000 tons per year.

(Here follow a number of statistics in regard to the iron and steel production of the United States.)

The manufacture of steel from pig iron by the Thomas-Gilchrist basic process is carried on at only one American establishment. In the refinery process a number of works use basic lining; the acid lining is, however, more common.

The problem of the direct production of malleable iron from the ore also occupies the minds of engineers on the other side of the ocean, and a great number of patents directed to this end have already been granted. The only extensive works now in operation, the Carbon Iron Co., at Pittsburg, produce 40,000 tons yearly, by a method which is not strictly a direct process. A bloom is indeed made directly from the ore in a reverberatory furnace, but in order to produce iron (steel) which may be brought under the rolls, it is necessary to plunge this bloom into a bath of pig iron, by which means a workable ingot is obtained. If this is the case with the exceedingly rich ores of Lake Superior, there can be no doubt that the direct production of malleable iron from the ore under less favorable conditions would be a matter of much greater difficulty.—Translated for the SCIENTIFIC AMERICAN from the *Schweizerische Bauzeitung* by Prof. S. B. Newbury, of Cornell University.

* The whole extent of the coal fields of the United States is twelve times as great as that of England, and the output of coal will soon equal that of the latter country.

ROYAL NAVAL EXHIBITION.

THIS, one of the most promising of recent exhibitions, was formally opened to the public on May 2, by H.R.H. the Prince of Wales. The opening ceremony took place, says *Iron*, in a large marquee erected in the grounds of the exhibition, and, in spite of the wet weather, was attended by a brilliant company. After the presentation of an address to the Prince of Wales, the gold key of the door of the model lighthouse was handed to the Princess. As the door moved on its hinges a minute but brilliant light appeared at the top of the model, and the royal standard was unfurled on the flag staff of the full-sized model in the grounds, a gun was fired, and a flourish of trumpets announced the close of the ceremony, the royal party afterward being conducted through the exhibition.

The exhibition, which is held in the grounds of the Royal Hospital at Chelsea, occupies an irregular area of about 15 acres, lying between the Royal Hospital and the Thames embankment. In the Franklin gallery will be found a large collection of the Franklin relics which were obtained by the expeditions of Captain Austin, R.N., Sir Edward Belcher, R.N., Captain Collinson, R.N., and others; portraits of all the most distinguished arctic explorers, from Sir Hugh Willoughby downward; numerous pictures illustrative of arctic scenery and adventure: various miscellaneous relics, many of which have never before been exhibited; some sledge flags, instruments, and natural history curiosities; and a large life-sized model of an arctic encampment on the ice. The Cook gallery contains the chief exhibits of the Navigation Committee, the collections including special appliances which have been used or suggested in connection with naval signaling by day and night; lights, buoys, and beacons; exhibits illustrative of meteorological facts and theories; compasses and nautical instruments of all periods; a series of British charts; working models, showing the course of the Gulf Stream and of other ocean currents; some fine models of noted lighthouses; and some ingenious devices for deep sea sounding. The eastern end of this gallery, and the whole of the Seppings gallery, are occupied by the exhibits of the Models Committee. These include boat-lowering and life-saving apparatus; marine engines; models of ships of all periods; models of boats and rafts; and two large tables, on one of which is shown, by means of tiny models made to scale, the strength of the fleets on each of our foreign stations at the present time, while on the other may be seen an imaginative representation of her Majesty on board the Victoria and Albert, preceded by the Trinity yacht and the Enchantress, and accompanied by the Prince of Wales in the Osborne reviewing all the remaining ships of the navy at Spithead.

In the Seppings gallery, which is named after Sir Robert Seppings, who was one of the surveyors of the navy from 1813 to 1832, the collection of ship models is singularly complete, and is undoubtedly the best that has ever been seen. Among the celebrated vessels here are the Great Harry, Sovereign of the Seas, Royal George, Victory, Shannon, Queen Charlotte, Duke of Wellington, Alexandra, and a hundred others. There are also models of types of all the classes of men-of-war now under construction, as well as of numerous foreign war ships that have been built in England, not omitting the Almirante Lynch, the destroyer of the unfortunate Blanco Encalada, and the famous Huascar. Close by are arranged models of many of the finest ocean passenger steamships, such as the Umbria, Dunottar Castle, Orotava, Empress of India, etc. The majority of the war ship models have been lent by the Admiralty, and come from Greenwich; the steamship models are for the most part lent by the various companies, some of which have built separate kiosks in the grounds for their exhibits.

In the grounds, at the extreme southeast corner, stands the full-sized model of the Victory; in the center is the lake, and on the west is the full-sized model of the new Eddystone lighthouse; and scattered about are separate pavilions, all of which contain something to interest or amuse. The St. Vincent gallery is almost exclusively devoted to ordnance exhibits, and within its walls are to be found specimens of nearly every kind of gun and small arm that has ever been used in the navy, from an iron serpent of Henry VI., and a breech-loading paterero of Edward IV., to the latest 4·7-inch quick-firing gun; and from the musket of 1619 to the most recent revolver. There are also projectiles of every sort, boarding pikes and axes, rockets, range-finders, automatic guns, and all the kindred apparatus of destruction.

In the Armstrong gallery, the most noteworthy exhibits are a full-sized section of her Majesty's ship Victoria's turret, showing one 111-ton gun on its hydraulic carriage; a full-sized section of the box-battery of a modern iron-clad, armed with 4·7-inch and 6-pounder quick-firing guns; a 9·2-inch breech-loading gun on Vavasseur center pivot mounting; a 6-inch gun on hydro-pneumatic mounting; and a number of various quick-firing guns.

The Camperdown gallery contains the torpedo and electrical exhibits, the armorplate and shipbuilding exhibits, and the exhibits of ships' telegraphs and of steam capstans and windlasses. The marvelous development of the Whitehead torpedo is well shown; and all varieties of mines, infernal machines, and torpedoes, save only the Brennan, are to be seen.

A comparatively small building in the southwest corner of the eastern grounds is devoted to machinery, and concludes the list of galleries. Almost adjoining it is the building which is occupied by the electric light plant of the exhibition, and which contains engines and dynamos of over 1,100 collective horse power, supplied by Davey, Paxman & Co., Colchester. The boilers are ten in number, of the locomotive type, each made to work at 140 lb. steam pressure, and are tested by hydraulic pressure to 250 lb. per square inch. Each boiler contains 705 square feet of heating surface, and 19½ square feet of grate surface. The boilers are of steel, the fireboxes being of Davey, Paxman & Co.'s well known mild steel. They are plated up and the holes drilled in position, and the work is done by most modern machinery.

Steam passes from the boilers into a steam receiver common to the whole of them. This receiver is made in lengths of 6 feet 6 inches, which is the length from center to center of each boiler, and these with their flanges are welded up in one piece, and the whole is a very excellent piece of work. By this system Davey, Paxman & Co. are enabled to shut off one boiler, or open up any of the boilers at a moment's notice. The boilers are placed as follows: One battery of eight in the electric light shed, and one battery of two in the Camperdown gallery, thus making ten in all. Each boiler is provided with an independent injector, and there are two of A. G. Mumford's duplex pumps, either of which is sufficient for feeding the boilers. It will thus be seen that every care and provision has been made to keep up the supply of water.

Fronting the electric light shed, and embedded in the earth, is the North Sea trawler Heroine, of 40 tons, rigged as a ketch and fully equipped. She is lent by the Mission to Deep Sea Fishermen. Behind her

towers Mr. Webster's model of the Eddystone lighthouse. This model is, so far as appearance is concerned, an exact reproduction of the lighthouse as it was erected from the designs of Sir J. N. Douglass, F.R.S., and is 170 feet high, 35 feet 6 inches in diameter at the base of the curved part of the structure, and 19 feet in diameter at a point 6 feet below the lantern platform. The lantern is 14 feet in diameter and 16 feet 6 inches high, and within it is a double group-flashing dioptric electric light of the fourth order, composed of Chance reflecting lenses only, and containing an arc lamp of 5,000,000 candle power—the most powerful in the world.

The other great model is that of the Victory. It is full sized, and although, perhaps, it does not exactly reproduce the external appearance of the hull of the vessel in her Trafalgar days, it is, upon the whole, so exceedingly well done, and apparently so substantial, that the impression conveyed is that the real Victory has by some magic been planted in the grounds of Chelsea Hospital.

In the kiosks and pavilions which are scattered about the grounds, and some of which are remarkably handsome structures, will be found the exhibits of the Peninsular and Oriental Steam Navigation Company, the Thames Iron Works and Shipbuilding Company, the Royal Mail Steam Packet Company, Messrs. James and George Thomson (Limited), the Fairfield Shipbuilding and Engineering Company, the Maxim-Nordenfelt Company, the Wilkinson Sword Company, Messrs. Siemens Brothers & Co., and the Babcock & Wilcox Company.

There is also an arctic pavilion, the exterior of which conveys a good idea of an ice hummock, while in the interior is a representation of her Majesty's ship Investigator, nipped in the pack ice in October, 1850.

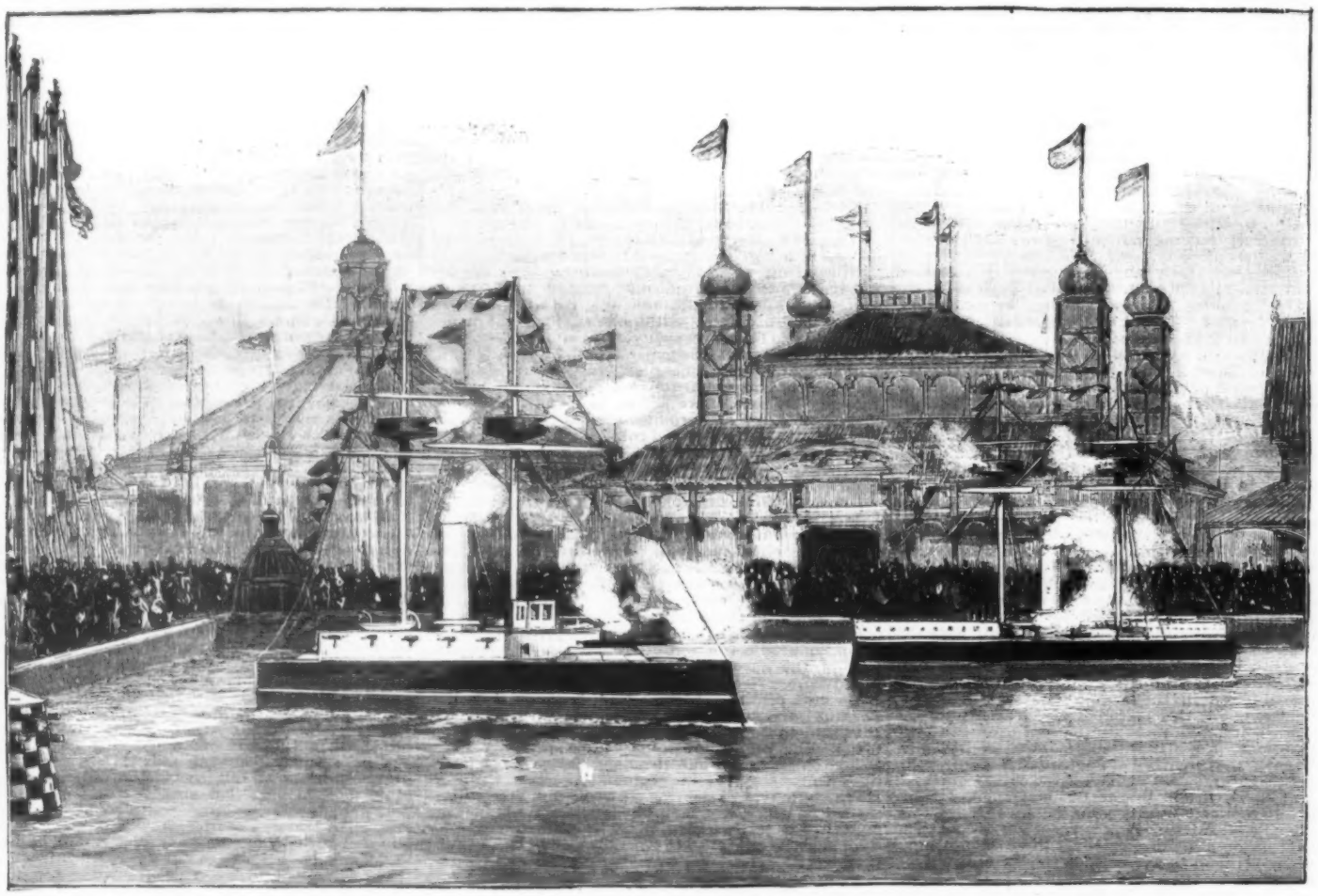
A MINIATURE NAVAL BATTLE.

AT the Naval Exhibition, now going on in London, is an artificial lake, which is one of the great attractions of the place. It is a solid concrete basin 250 ft. long by 150 wide, and is 5 ft. deep in the center, 4 ft. at the shallowest part. In one corner there is a little covered dock where two miniature ironclads are housed. These vessels are named the Majestic and Edinburgh; they are each 35 ft. long and 6 ft. beam, their engines and power being identical. They are models of the most recent 10,000 ton battle ships. The Majestic is armed with two 100 ton guns mounted *en barbette*, and carries an auxiliary battery of ten 6 in. quick firing guns, and also machine guns in her fighting top. The Edinburgh, on the other hand, is a turret ship with an armament of four 47 ton guns in two turrets. Her auxiliary battery contains only six quick-firing 6 in. guns, but she has two fighting tops with machine guns in each.

It is intended that naval maneuvers shall be performed by these vessels on the lake, and that miniature contests shall take place between them. How the vessels are maneuvered and fought is as yet a secret, but it is stated that, whatever may be the power employed, it is *not* electricity.

A trial contest between these two vessels is thus described by the *Marine Engineer*:

The Majestic, with a blue ensign flying, and the Edinburgh, which was distinguished by a red flag; in obedience to a signal from the flagstaff, the Majestic proceeded slowly into the arena. She executed several maneuvers, and interchanged a number of signals with headquarters. The effect of these messages was apparent by the fact that she was at once prepared for action. The guns in her barbettes went to the loading position, and the clouds of smoke which appeared from her funnel showed that her fires were being forced and steam being raised to its full pressure. At this juncture a torpedo boat, flying the red ensign, appeared on the scene, and went direct toward the barbette ship. The latter opened fire with the machine guns in her tops, and then discharged several of her 6 in. guns, but, failing to check the advance of the torpedo boat, she trained the barbette guns upon her. Just as the little craft was about to launch her torpedo, the broadside was poured into her, and as the smoke cleared away the little vessel—which was only 4 ft. long—was seen to be going down, and she soon sank, stern foremost. The Majestic, however, was not left in undisturbed possession of the arena, for the Edinburgh now proceeded to avenge the destruction of the torpedo vessel. The action commenced with a shot from one of the forward guns of the Majestic, and firing became almost continuous. The first blood was drawn by the Majestic, which brought down her opponent's foretop mast and colors by a well-directed broadside, delivered after the Edinburgh had made an unsuccessful attempt to ram her. But the turret ship soon gained a more substantial advantage. Another flag having been hoisted, she awaited the attempt which the Majestic in her turn made to use her ram, and as soon as the two ships were at close quarters, discharged her heavy guns, and dismounted the 100 ton gun in the enemy's forward barbette. Now half the heavy armament of the Majestic was disabled, and the Edinburgh soon followed up this advantage by getting across the bows of her opponent. She thus escaped the fire of the only remaining heavy gun, and was enabled to fire her whole armament at the crippled enemy with the result that an explosion occurred on board the latter. The Majestic was now evidently *in extremis*, her fire ceased, and she appeared to be sinking, her colors were soon hauled down, and the battle was at an end. Whether we may expect always to see the turret ship beat the barbette ship we cannot, of course, tell. In this particular case the exposed position of the Majestic's guns in the firing position caused her to be at a disadvantage, and possibly if this disaster is constantly repeated, it may be used as an argument against the further building of this class of vessel for the navy, though it is not pretended that anything except spectacular effect is aimed at by this display.



THE LONDON NAVAL EXHIBITION—NAVAL BATTLE BETWEEN MINIATURE WAR SHIPS.

THE TRANSANDINE RAILWAY.

THE Transandine Railway, which is to connect the series of railways across South America, joining the river Plate with the Pacific coast of Chili, presents various engineering difficulties. These principally relate to tunneling and overcoming great differences of level, due to the lofty mountains which form such a suitable frontier between Chili and Argentine. The railways formerly constructed extended to Mendoza from Buenos Ayres, a distance of 648 miles, of which 428 to Villa Mercedes were built by Messrs. J. E. & M. Clark & Co., the concessionaires and constructors of the Transandine line, and the remaining 220 miles by the Argentine government. The railway connects with this line at Mendoza, and passing over the mountains, joins existing railways at Santa Rosa, 40 miles from the frontier and 53 miles from the coast. The length of the new railway is 149 miles, of which 109 miles are on Argentine territory and owned by an English company, the Buenos Ayres and Valparaiso Transandine Railway Company, Limited, while the 40 miles in Chili are owned by Clark's Transandine Railway Company. Mendoza is 2,376 ft. and Santa Rosa 2,704 ft. above sea level, but between these points the line rises to 10,460 ft. The tunnels, which are at the point where the line attains its highest level above the sea, extend in all to 15 kilometers (9·32 miles), and to overcome a part of the difference in level within a short distance, and at suitable working gradients, it has been found necessary to construct a spiral tunnel, 2,061 yards long.

Fig. 2 appended is a plan of the works from Juncal, in Chili, to the Quebrada Navarro in the Argentine Republic, the distance by the line being about 14 miles. In this part of the line are included all the summit tunnels, and the altitudes are indicated on the profile, Fig. 1. The greatest height attained by the railway is 3,188 meters (10,460 ft.), while the summit level is 3,800 meters (12,467 ft.) above sea level. In that distance there are, as shown, eight tunnels, the longest being the summit tunnel, having a length of 5,065 meters, or 5,540 yards. The spiral tunnel is at Portillo. The radius of the curve is 200 meters, equal to nearly 10 chains radius. Of these eight tunnels, seven are in sidelong ground admitting of openings being made, so that a greater number of working faces are obtained, thus enabling the excavation to be done in shorter time than if worked only from the ends. The maximum grade is 8 per cent., and this extends for a distance of 15 kilometers (9·32 miles).

It may here be stated that the tunnels are for single line, the area being 18·51 square meters (199·244 square feet), the height being 5·30 meters (17·38 ft.), the width 3·40 meters (11·15 ft.), and the radius of arch 2 meters (656 ft.) A section is given (Fig. 3). It is in the boring of these tunnels, or rather in the means adopted, that Messrs. Clark have overcome extraordinary difficulties, and a detailed description of the plant will be interesting.

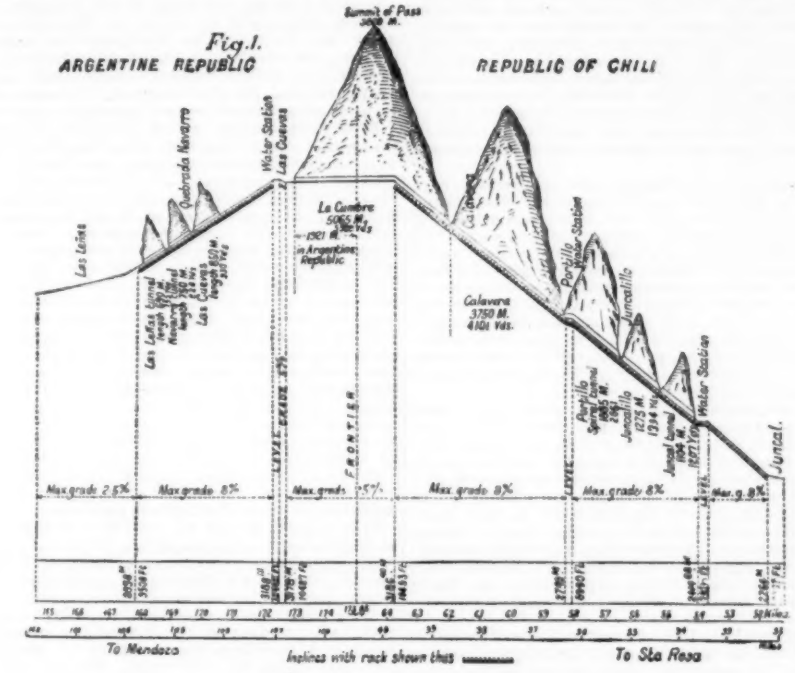
The installation may be said to be unique, as it is probably the first time that the power for compressing air for the drills has been conveyed for such a long distance by electric cables. In our previous article we referred to the reasons which made such an arrangement almost imperative. In the first instance the absence of fuel on the spot and the enormous expense which would have been involved in obtaining it precluded the use of any but natural power for driving the air compressors. Secondly, since sufficient water power could not be obtained near the faces of the tunnels, which have to be drilled by machines, it was necessary to place the turbines where the power could be obtained and to transmit it to the compressors. Upon the advice of their engineer, Mr. Alfred Schatzmann, who had had great experience on the St. Gothard and other European tunnels, Messrs. Clark adopted an electrical transmission of power. Mr. Schatzmann planned the arrangement of the installations, and fixed the power of the machines required at each.

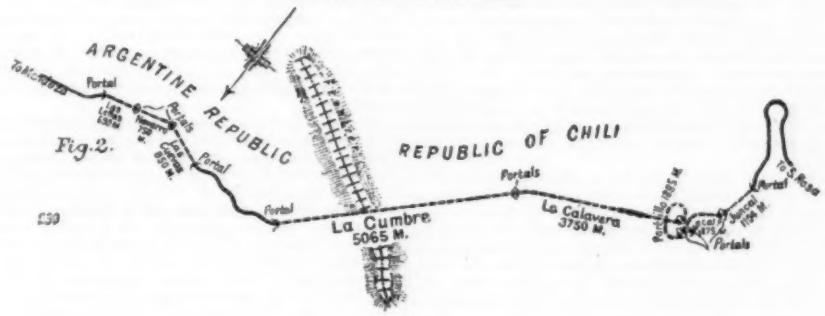
The disposition of the various departments of the works thus becomes a matter of interest, and before dealing at length with the plant itself, we shall refer more particularly to its arrangement and general efficiency. Fig. 4 shows the districts in which the various

works are placed. There are three installations, one upon the Argentine and two on the Chilian side of the Andes, each being distinct in all points, except that primary stations on the Chilian side are both located at Juncal. Each installation has a primary station where the turbines and dynamos are situated, and a secondary station with electromotors and air compressors.

The Chilian installation consists of two primary stations under one roof at Juncal, with secondary station at Juncalillo and Calavera, as shown on plan, Fig. 4. There are separate cables for transmitting the power from Juncal to Juncalillo and to Calavera. The power for driving the turbines is obtained from the Quebrada Juncalillo, the water being conveyed from the settling tanks to the turbines, a distance of 1,300 meters (about 1,420 yards), by a double line of 20 in. diameter steel pipes.

The primary station at Juncal for this installation consists of six Girard turbines, each giving 80 horse power effective at a speed of 700 revolutions per minute, receiving 50 liters per second (11 gallons) under a horse power. At Juncalillo the cables are attached to six electric motors, similar to the 80 horse power primary dynamos, but owing to the loss in the line they will only run at 600 revolutions. The motors have a commercial efficiency of 90 per cent., and the six will give a power equal to 401·8 horse power by 0·90 = 361·67 horse power. The motors running at 600 revolutions per minute drive through a shaft running at 300 revolutions six air compressors at a speed of 180 revolutions per minute. Assuming the loss of power due to shafting and belting at 5 per cent., the power available for driving compressors is 361·67 horse power by 0·95 = 343·58 horse power. The compressors, six in number, each take in 9 cubic meters of air (317·84 cubic feet) per minute when working at a speed of 180 revolutions per minute, and compress it to six atmospheres absolute, the total being 54 cubic meters (1,907 cubic feet), which produce 9 cubic meters (317·84 cubic feet) at six atmospheres absolute (88 lb.) Assuming that each cubic meter of air taken in and compressed to 6 atmospheres requires 6·15 horse power, the powers absorbed by the compressors will be 54 by 6·15 horse power = 332·10 horse power, which deducted from the power available, 343·586 horse power, leaves 11·486 horse power available for the workshops and electric light.





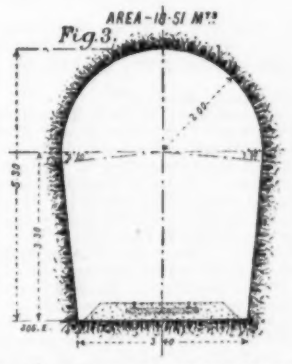


FIG. 3. SECTION OF TUNNELS ON TRANSANDINE RAILWAY.

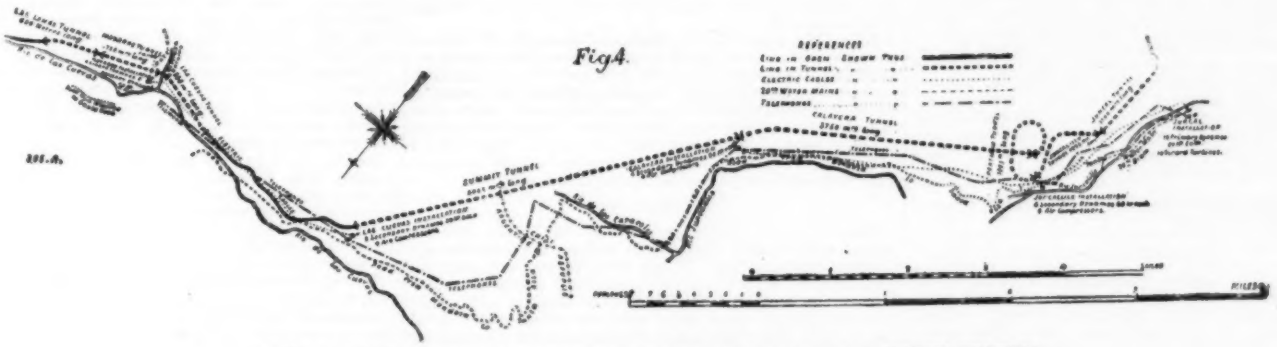


FIG. 4.—PLAN SHOWING ARRANGEMENT OF DRILLING PLANT FOR SUMMIT TUNNELS.

THE TRANSANDINE RAILWAY.

pressure of 170 meters head of water (557·8 ft.) The total power given out by the turbines is therefore 80 horse power by 6 = 480 horse power effective. Each 80 horse power turbine is coupled directly on to the shaft of an 80 horse power dynamo, consequently there will be no loss of power in transmission from the turbines to the dynamos. The dynamos, each absorbing 80 horse power and working at 700 revolutions per minute, have an efficiency of 90 per cent., an electrical output of 400 volts and 135 amperes. They are grouped in two groups of three dynamos each, each group having a main and return transmission cable. A great advantage is gained in having two groups, as should accidents or other cause prevent one from being worked, the whole of the tunneling would not be stopped. the cables have been calculated from 400 volts by 3 = 1,200 volts with a section of copper of 0·233 in., and having a conductivity of 98 per cent. of pure copper, the loss in the cables main and return being per cent.

The secondary station at Juncalillo is 3,000 meters (about 3,281 yards) from Juncal, the power available being 2 by 3 by 80 horse power by 0·91 by 0·93 = 401·8

The installation of Juncal Calavera is very similar to the Juncal Juncalillo, described above. The turbines are in the same shed and take their water from the same source. These and the dynamos are also of the same size and power, but since the distance Juncal-Calavera is 7,000 meters against 3,000 meters for Juncal-Juncalillo, the power available at Calavera for driving the compressors is proportionally less. The cables, one main and one return, have a section of copper of 0·271 in., and carry 1,600 volts (the product of four dynamos at 400 volts each) with a loss of 12 per cent. main and return. The power available therefore for driving the four compressors at Calavera (which are the same size as those at Juncalillo) is 4 by 80 horse power by 0·91 by 0·88 by 0·90 by 0·95 = 219·10 horse power, the compressors requiring 6·15 by 36 = 221·4 horse power.

Turning now to the Argentine installation, the water power upon this side is derived from the Quebrada Navarro (Fig. 4), the water being conveyed to the turbines from the settling tanks, a distance of 350 meters (383 yards), by a single line of 20 in. diameter steel pipes. Owing to the difficulties of transport upon the Argentine side of the mountains, 80 horse power dynamos were found to be too heavy for transport, and machines of half the power were therefore adopted. At the primary station at Navarro four Girard turbines similar to those at Juncal, but designed to work with a pressure of 115 meters head (377·3 ft). with 75 liters of water per second (16·5 gallons), are used. These give each 80 horse power effective at 700 revolutions per minute. Each turbine drives two 40 horse power dynamos directly from its horizontal shaft, one on either side. The machines are in two groups, each of two 80 horse power turbines with four 40 horse power dynamos. The turbines, however, are supplied by one pipe. One group can be worked independently of the other, should any accident arise, provided it does not affect the source of water supply. The primary dynamos absorbing 40 horse power have an efficiency of 90 per cent. with an electrical output of 250 volts and 107 amperes at 700 revolutions per minute. The cables transmitting the power have a section of 0·221 in., and the loss in main and return between Navarro and Las Cuevas, a distance of 3,000 meters, is 8 per cent. The 30 horse power motors at Las Cuevas are similar to the dynamos at Navarro, and at 600 revolutions per minute have an efficiency of 89 per cent. The power therefore available for driving the compressors is 2 by 4 by 40 horse power by 0·90 by 0·92 by 0·89 by 0·95 (allowing 5 per cent. for loss by friction in shafting and belting) = 224·74 horse power. The four compressors are of the same type as those for the Chilian installations, and calculating upon the same basis, *i. e.*, 6·15 horse power, to compress one cubic meter of air to six atmospheres, the power required is 36 by 6·15 = 221·4 horse power.

Dealing generally with the three installations, the air is conveyed from the compressors into large steel reservoirs and from thence to the drills in 4½ in. wrought iron pipes. The drills are of the Ferroux type, are mounted upon carriages in groups of six, and are run forward on rails to the face. As the greater part of the tunnel is on a grade of 8 per cent., special arrangements have had to be made for clearing the debris. Where it has to be hauled forward to the open air, winches are used; and where it may run out on a down grade, arrangements are made whereby the full wagons draw the empty wagons to the face. The movements are controlled by special brake drums made by Messrs. Bradley & Craven.

The several stations are connected by telephone, and similar communication is established between the settling tanks and the turbine house, so that although the works are widely separated, the same initial power which is, by the various processes, converted into active work at the rock face affords the means of instant and easy communication with all parts on the works. The workshops, which, by the way, are built of stone found in the district, with wooden roofs sent from England, are lighted by electricity generated in a separate 10 horse power dynamo.

The Girard turbines have been supplied by Messrs. Escher, Wyss & Co., Zurich, the dynamo and electrical motors by the Oerlikon Company, also of Zurich, and the air compressors by Messrs. Buckhardt & Co., of Basle, firms formerly associated with somewhat similar work in connection with Swiss tunnels. The Ferroux drills were made by Messrs. Demange & Satre, Lyons, under the supervision of the patentee. The cables are by Messrs. Siemens. As in our next article we intend to illustrate and describe these, this name reference here is sufficient.

Reports have been received from Buenos Ayres that the first three sections from Mendoza to Uspallata, 91 kilometers (56·546 miles), had been opened to traffic under the guarantee of the government, and that the

next section of 30 kilometers (18·641 miles) in length, to Rio Blanco, would soon be ready. This will bring the portion completed to 121 kilometers (75 187 miles), leaving 54 kilometers (33·5 miles) on the Argentine and 49 kilometers (26 miles) on the Chilian side (on which the earthworks are well advanced) to complete communication between the Atlantic and Pacific Oceans; 93 per cent. of the distance from ocean to ocean can now be traversed by rail, and the works are far advanced upon the remaining 7 per cent.—*Engineering.*

ON THE DURABILITY OF PICTURES PAINTED WITH OILS AND VARNISHES.*

By A. P. LAURIE.

WHEN we look at the Van Eyck, No. 186 in the National Gallery, we are at once struck with its wonderful state of preservation. The reds, probably produced by glazings of lac, or Brazil wood, or kermes lake, over a yellow or red ground, seem certainly to have slightly faded, and turned brown, when compared with fresh preparations of the same lakes made from the old receipts; but they are in very fair condition, and the green on the wife's dress is marvelously brilliant. This green is worthy of special attention, as it seems to be agreed among the authorities on these matters that it can only have been produced by a glazing of verdigris, a pigment which we now know to be of a most dangerous character, turning black, and corroding and destroying other colors. The oranges in the corner are apparently painted with orpiment, another dangerous color to use.

With reference to the reds, I have already mentioned the three lakes, which are most commonly referred to in old receipts, madder being hardly ever mentioned. Of these, Brazil wood is very fugitive, turning a dirty brownish red, and fading very much if only exposed to sunshine for a few days. Lac lake, though better than the last, is not a permanent lake, and of kermes very little is known beyond the fact that it yields a permanent dye. Unfortunately these lakes, when prepared from the old receipts, are so much alike that it is impossible to identify them on a picture. Judging, however, by these receipts, one lake is as likely to have been used as another.

In this picture, then, painted early in the fifteenth century, we probably have verdigris, a notoriously fugitive pigment; orpiment, a pigment very apt to change; and a lake which, assuming that kermes is a permanent color, may or may not be permanent, according to which of the three lakes above mentioned has been used.

It cannot, then, be held that the preservation of the picture is due to the pigments used, and we must, therefore, look elsewhere for an explanation of its freshness.

If, then, the secret does not lie in the pigments, it must lie in the vehicle; and this leads us to consider what properties a vehicle must have, to produce so remarkable an effect.

This question is very easily answered.

It has been again demonstrated by Prof. Russell and Captain Abney, in their report on water colors (1888), that most fugitive pigments are permanent, if protected from moisture, and a still larger number, if protected both from air and moisture. If, then, we can obtain a vehicle which will really protect the particles of the pigment from moisture, we may use with safety many pigments that are now regarded as fugitive.

At this point one is apt to think that the inquiry is concluded, as we are accustomed to assume that ordinary varnishes and oils do preserve surfaces from the action of moisture; but, unfortunately, if a sufficiently delicate test is applied, this is not found to be so. The method I have devised for doing this is to use as a pigment ignited sulphate of copper, which is, of course, a very hydroscopic body. If we grind a little of the ignited sulphate with linseed oil, and paint it out on a glass slide, we get an enamel-like white surface, with sometimes a slight greenish tinge in it.

If this is placed in a desiccator to dry, it remains the same in appearance; if, however, when dry, it is exposed to the air of a room, it gradually turns green and transparent; or if it is exposed under a bell jar beside a dish of water, the change takes place much more rapidly, twelve hours being often sufficient. If we now examine the slide under a microscope, we usually find that no definite crystalline formation is visible, but occasionally here and there are to be found complete crystals of sulphate of copper, due, apparently, to a slow aggregation of molecules in the colloid linseed oil.

I shall begin by describing the experiments I have made on linseed oil alone.

LINSEED OIL.

The linseed oil of modern commerce differs in several important particulars from that used by the old masters. Hot pressed from adulterated seed, refined by the addition of sulphuric acid, and then probably further adulterated with other oils before it is put on the market, it is a very inferior product. The oil of the old masters seems to have been cold pressed from pure seed, and then refined by exposure to sunlight, and washing with water.

In converting it into boiled oil, various methods and substances were used, such as exposure merely to the sun till it thickened; boiling it with bone ashes and pumice; boiling it with ignited sulphate of zinc; boiling it with litharge or with white lead, or with umber; or exposing it to the sun exposed in leaden dishes, or mixed with white lead.

The modern practice is probably, in many cases, similar, salts of manganese having been added to the list, and such substances as sulphate of zinc having been abandoned.

My impression from the study of the old receipts is that, probably, in most cases litharge or white lead was used, just as it is most commonly used now. We have, then, to look rather to the earlier stages of the preparation of the oil to find any serious difference between ancient and modern practices.

With a view to finding whether the capacity of linseed oil for resisting moisture would be improved by following any of the old methods, I tried the following experiments. I obtained:

1. A sample of ordinary pale drying oil of the best quality.
2. A bottle of drying oil from one of the leading firms of artists' color men.
3. A sample of Bell's medium from Messrs. Bell & Co., of 'Oxford Street. This medium is prepared by cold pressing carefully sifted seed, and then keeping the raw oil at a temperature of about 100° C. for some weeks, until it becomes thick and viscous. This "fat oil" is then thinned with oil of spike for use.
4. I obtained some raw oil, cold pressed, from sifted English seed, which I then refined in the following manner: A bottle was filled one-third full of salt water and sand, and one-third full of oil, and was placed out in the sun, with a loose cap over the top, for four weeks. By the end of that time no more precipitate was formed, and the oil was drawn off, filtered, and converted into boiled oil by heating to 120° C. for 120 hours with borate of manganese.
5. Another portion, after refining, was converted into oil, by heating strongly for three hours with bone ashes, adding ignited sulphate of zinc, and allowing it to settle and stand in the sun, according to an old German receipt, which is quoted by Eastlake in his "History of Oil Painting." Slides were painted out with these different oils, mixed with sulphate of copper, and, after having been dried by a desiccator, were exposed to moisture. They all turned green at approximately the same rate, and repeated experiments did not show that one had much advantage over another. If a slide is varnished with oil, after being dry, it, of course, resists a little longer; but four layers of such varnishing only protect the slide for three days instead of one.

As far, then, as experiments are concerned, there seems to be no reason to suppose that the pure oil, sun refined, has much advantage over the commercial oil, or the different methods of converting it into boiled oil exercise an appreciable effect. Only one point seemed to remain unsettled. It seemed possible that the old oil, imperfectly pressed, might be superior to that obtained by the hydraulic press. In order to test this, I had some fresh seed pressed, and took samples during the pressing, dividing the oil into three parts. Taking the first part of these, I refined it, boiled it with borate of magnesia, and tested it. The moisture penetrated through it as before.

These experiments seem to show, then, pretty conclusively, that linseed oil, no matter how pure or how carefully refined, or in what way it is converted into boiled oil, cannot be depended upon to protect a surface from moisture. In the course of these experiments I was struck with the fact that linseed oil which had been kept for some time after it was dry in the desiccator seemed to resist better than lately dried oil, when exposed to moisture. Three weeks was found to make a considerable improvement, and two months still further improvement. These experiments are being continued, with a view to finding at what point the improvement will cease.

When we consider the nature and constitution of linseed oil, I do not think we need be surprised at its permeability to moisture. Besides containing linoleine, it also contains considerable quantities of non-drying fatty acids, which being unaltered during the oxidation of the linoleine must tend to produce a spongy and porous surface. According to Allen, the dried film contains free glycerine, which must not only tend to increase its porosity, but also to act as a carrier of moisture. Taking these different facts into consideration, the passage of moisture through linseed oil is not surprising.

I should like to refer here to a theory which has been recently advanced, that lead driers are injurious to pictures on account of the formation of lead soaps. As far as these experiments are concerned, we have no confirmation of this; and I confess that the theory seems to me a very startling one in the light of the fact that the white lead used by the old masters was prepared by the Dutch process, and therefore contained large quantities of lead hydrate, and of the fact that the oldest receipt I am familiar with for preparing drying oil devises that this should be done by boiling with oxide of lead.

When Mr. Scott Taylor tells us that the Venetian painters were accustomed to grind their white lead repeatedly in vinegar, I can only suppose that chemists, like poets, are sometimes caught nodding. It seems to me more probable that treatment with lead salts may remove some of the fatty acids other than linoleic acid as lead soaps. I do not find, however, that the oil which rises to the surface of ground white lead protects from moisture any better than ordinary oil.

WALNUT OIL.

Walnut oil is frequently referred to in the old receipts, and seems to have been largely used by the old masters for painting. It can be prepared by pressing the kernels of walnuts after slightly warming them. The walnuts should be about three months old. The oil obtained is very pale, and dissolves white lead freely on boiling, becoming darker in color. I prepared a little by boiling the kernels of the walnuts with water, after pounding them in a mortar, roughly separating the oil which rose to the top, dissolving the oil in ether, filtering, and evaporating off the ether. I then converted this oil into a boiled oil by heating it with white lead. On testing it with the sulphate of copper, I found that moisture rapidly penetrated, showing that it is no better in this respect than linseed oil. As these were the two oils which were used by the old masters, the protection of their pigments cannot have depended upon the moisture of the oils used.

RESINS.

In order to test how far pure resins will protect the sulphate of copper from moisture, I dissolved them either in spirits of turpentine or in benzole, ground the sulphate of copper with the solution, and painted it out on a glass slide. I have not attempted an exhaustive examination of resins, but have contented myself with a few typical ones, namely, colophony, mastic, Sierra Leone copal, and amber. The varnishes were all prepared by first fusing the resin and then gradually adding the spirits of turpentine to the fused mass.

The change of appearance on exposing one of the slides thus prepared to moisture was quite different to the appearance in the case of oil. The surface became an opaque greenish blue in the course of a few hours in the case of colophony, mastic, and Sierra Leone copal, but after that there was no further change. On then examining these slides under the microscope, this appearance was explained. The whole surface was rough and covered with blue cones of sulphate of copper with unaltered white plains between. Apparently the varnish on drying became full of small cracks or holes, through which moisture penetrated, but in itself resisted the passage of moisture. These holes were so close together as to give the whole surface a blue appearance when examined with the naked eye. The one exception to this was the amber varnish. It resisted the attacks of moisture for weeks without change. I think, however, that we may consider that such solutions of resins protect a surface from moisture sufficiently well for all practical purposes. The slight change taking place in the sulphate of copper does not go any further, and would, I think, be imperceptible in the case of a fugitive pigment.

I need hardly point out, however, that such solutions are quite unfit to be used as mediums in place of oil, and that the surface formed is brittle and not very durable.

OLEORESINOUS VEHICLES.

Eastlake, in his "History of Oil Painting," devotes himself principally to trying to determine what medium was used by Van Eyck and his immediate followers. As his book is the most important work on this subject, and he has devoted immense pains to investigating all the documentary evidence, the theory he advances requires specially careful examination.

Briefly, his theory is this: that the Flemish painters ground their colors in oil; that they prepared a varnish, by dissolving a resin, preferably amber, in oil, and that they mixed a little of this with the color. He claims that such a medium protects the pigment from moisture, and that it is only necessary, in the case of specially fugitive pigments, such as yellow lake, verdigris, etc., to increase the proportion of varnish and diminish the proportion of oil, in order to effectually lock them up, and protect them from the action of a moist climate. This he calls the oleoresinous vehicle; and while undoubtedly showing that this, in all probability, represents their usual practice for ordinary pigments, I think he fails to make out that they relied upon this method in the case of notoriously fugitive pigments. In fact, curiously enough, as I shall presently show, any evidence he brings forward points in quite a different direction. At the same time, he quotes from a sufficient number of authorities to show that he correctly describes their general practice; a practice for which there are sufficient reasons, apart from the question of the preservation of specially fugitive pigments.

It has been shown by Professor Church that even so hard a resin as copal, when dissolved in a volatile medium, after a year becomes covered with minute cracks; that this is also true of copal dissolved in the usual quantity of oil necessary to make a varnish. But he finds that if a copal oil varnish is mixed with a certain proportion of oil, it forms a surface which is hard, and, therefore, preferable to oil alone, which is soft, but which does not crack. There seems to be no doubt, therefore, that apart from other considerations, the mixture of a resin dissolved in oil with oil produces the most permanent surface. It remains to be seen whether such a medium has the quality claimed for it by Eastlake of protecting the pigments from moisture.

In order to experiment upon this matter, I obtained (1) a very fine sample of a genuine copal varnish from Messrs. Freeman; (2) Mander Bros., Coburg varnish; (3) I dissolved Sierra Leone copal in my own pure linseed oil, and heated it till it became stringy, as directed in the old receipts; (4) I dissolved amber in the same way in the pure oil; (5) I boiled some of the amber varnish mixed with white lead till almost solid, and then diluted it with spirits of turpentine. I then prepared slides with these varnishes mixed with the sulphate of copper; comparing the slides painted with pure oil with slides painted with a mixture of oil and varnish, and slides painted with the varnish alone.

In some cases, the slides after drying were varnished with the mixture that had been used in painting them out. In making the varnishes, I mixed about one-third resin with about two-thirds oil.

None of these preparations resisted the attacks of moisture. Those containing varnish resisted a little longer than those merely containing oil, but the difference was probably due to the greater thickness of the protecting layer.

As far, then, as we can judge, by the sulphate of copper test, Eastlake's theory that an oleoresinous vehicle will protect a fugitive pigment is not correct. It seemed to me necessary, however, to check these results by some experiments made in another way, and I therefore determined to try whether such mediums would protect a fugitive pigment.

In order to reproduce, as near as possible, the conditions necessary in the case of one of the old masters, I prepared some Brazil wood lake, according to one of the old receipts, and after careful washing and drying, ground it with the following mediums:

1. Commercial pale boiled oil
2. Rowney's boiled oil.
3. My pure oil.
4. The pure oil mixed with amber varnish.
5. The pure oil mixed with copal varnish.

All of these faded when exposed to sunlight, and apparently faded at the same rate.

To confirm this result, I next rubbed out on two glass plates carmine ground in pure oil. After the two plates were dry, I put one away in the dark, and exposed the other to light. At the same time I rubbed out on two other plates carmine ground with pure oil and a little amber varnish, and exposed one of these to light. The two plates kept in the dark retained their brilliancy, while the two exposed to light quickly turned brown at the same rate.

I think that these experiments show pretty conclusively that whatever method may have been used to preserve fugitive pigments by the old masters, it cannot have been that of grinding colors with oil, and then mixing in a little oil varnish, as supposed by Eastlake.

In order, then, to solve this problem as to the nature of the vehicle used to preserve fugitive colors, it is necessary to lay aside the theories of such writers as Eastlake, and examine carefully such old receipts as are available. This is all the more necessary, as the

* A paper recently read before the Society of Arts, London.

word varnish is used so carelessly by writers on this subject, for they seem to think that all varnishes have similar properties, and therefore it does not matter whether the nature of the varnish is stated or not.

The result of a more careful and minute inquiry has been the discovery of an old medium of remarkable properties. It is too early, however, to say anything in public as to this medium, until it has been thoroughly tested. I, therefore, shall say nothing of it here, but reserve to some future date the complete statement of its preparation and properties.

Leaving this question, I will next describe the experiments we have made on the effect of a layer of varnish of different kinds over linseed oil.

Sulphate of copper was ground with linseed oil, painted out on glass slides, and allowed to dry in a desiccator. They were then varnished respectively with copal dissolved in oil, copal dissolved in turps, amber dissolved in turps, and mastic dissolved in turps. The first to give way and show the passage of moisture were the slides varnished with copal in turps and amber in turps; while the slide which resisted moisture longest was the one coated with mastic and turps.

I find that a good mastic varnish will protect for some weeks a slide which would otherwise turn green in a few hours.

The reason for the superior behavior of mastic is, I think, not far to seek. It forms a soft elastic coating over the elastic oil, which is more durable and less likely to crack than the hard brittle coating formed by the amber or the copal. Experiments upon other resins have confirmed this view. These experiments then add another argument in favor of the use of mastic varnish for pictures to those already known.

To repeat these arguments briefly: The use of an oil varnish for a picture has this objection, that it will turn yellow with age, or even, if it contains lead driers, as in most cases it does, dark brown with age, thus increasing the defects of an oil picture, and cannot be removed without great risk of destroying the coatings of color underneath; while, as has been shown by these experiments, it affords little or no protection to the picture from the action of moisture.

The use of copal or amber, dissolved in spirit, is also objectionable, because the varnish is difficult to remove. By using mastic, we have a varnish which, while affording the best protection to the picture from moisture, is easily removed and renewed, without any danger of injury to the picture underneath. This seems of special importance in a country like this, where pictures are exposed to the greasy, sticky dirt produced by coal smoke. As might be expected, from its capacity of keeping out moisture, mastic varnish also affords a good protection to white lead from the blackening action of sulphur gases.

It must not be supposed, however, that in selecting the best varnish for a picture, we have solved the problem before us. Not only can moisture readily penetrate through the back, but supposing the back to be protected, it is only a question of time for the moisture to penetrate through the front, as having once succeeded in passing through cracks in the varnish, it is able to move about freely through the oil underneath.

There is another danger in the use of an ordinary oil medium. There is no doubt that if certain pigments ground in oil are mixed together, they will act chemically upon each other. Such, for instant, as cadmium yellow and emerald green, which, if mixed together, rapidly turn black. At first sight this is difficult to understand, as it seems unlikely that dry particles of color, each isolated by a layer of oil, could act upon each other. When we remember, however, the complicated nature of linseed oil itself, and the complicated changes that take place while it is drying, resulting in the presence of free fatty acids, of glycerine, and of moisture, it seems quite possible that certain pigments could be dissolved and decomposed, and once in solution they would probably diffuse through the oil, even though the oil was dry, just as we know that salts will diffuse through solid gelatine.

Mr. Holman Hunt has got in his studio a remarkable example of such diffusion. A patch of emerald green placed on the canvas ran down until it came in contact with a patch of cadmium yellow; the blackening caused by this is not confined to the point of contact, but has gradually spread.

With a view to testing this point more carefully, I rubbed out on a glass slide two patches of cadmium yellow. When they were dry I rubbed over one of them some emerald green and over the other some boiled oil. When the boiled oil was dry I rubbed over that some emerald green, so that in the one case we had the emerald green isolated from the cadmium yellow by the thin layer of oil which rose to the top of the cadmium yellow in drying, and in the second case by the thick layer of oil which was purposely placed between them. After keeping for some time, both of these patches began to grow dark, the one with the thin layer of oil changing markedly, while the one with the thick layer of oil changed slightly. These films were then stripped off, cut in sections, and examined under the microscope. This can be very readily done by embedding such a film in paraffin wax, and cutting and mounting in the way used in the biological laboratories at Cambridge.

Though little could be seen in the case of the film with the thick layer of oil, it was quite easy to see, in the film with the thin layer of oil between the two colors, that the emerald green was unaltered, but that the top of the cadmium yellow was covered with a line of black spots, showing that the emerald green must have dissolved and diffused through the oil to attack the cadmium yellow.

These experiments, I think, show that we have not only in oil paintings to guard against external dangers.

We have, then, two policies before us. One is to obtain a medium which will effectually lock up pigments from external danger and from internal solutions and diffusions; and the other is, recognizing the imperfection of the medium we are using, to select pigments which are unaffected by the medium, and least likely to injury from external sources, such as moisture, and so on.

Apparently the most durable surface that can be produced with modern mediums is that obtained with a mixture of copal oil varnish and linseed oil.

Until, then, the proper medium is discovered, the best we can do is to paint our pictures with this medium and a carefully selected group of pigments, and then, as a further precaution, coat the pictures, when thoroughly dry, with a layer of mastic dissolved in turps.

DISCUSSION.

The Chairman, Dr. W. Holman Hunt, thought the observations which they had just listened to would be of the greatest possible value in teaching them what to avoid, though, for practical purposes, the inquiry had a somewhat negative result. Speaking of copal and amber, he might say that certain pictures painted by men who took the advice of Linnell and others had been remarkably well preserved, but in the case of one picture at South Kensington, which had been so treated, Mulready found certain inexplicable white spots upon it. At first it was impossible to account for these spots, and Mulready asked the authorities to let him take the picture to his studio to investigate it, and, if possible, to cure the defect. Upon examining the picture with a strong microscope, he found that each little spot was a round ring, and in the center there was a little circumference of the color which it had actually been before, but that outside there was the bare canvas. On examining it more carefully, Mulready discovered that these spots had been caused by the saliva of the people standing in front of the picture, the saliva as it dried having contracted the color. This was a proof that amber varnish was not sufficient to protect a picture. The picture was restored by Mulready, and a similar mishap had been avoided by placing glass in front of it. Many of the pictures painted with amber and copal had stood in a way which could not be expected from oil alone; they were not more substantial, but the color had been better preserved. One could not be certain about pictures painted by other people, but he might refer to one painted by himself in 1850, entitled "The Rescue of Christian Priests from the Persecution of the Druids." One priest had a robe of great brilliancy, with a white linen dress underneath, and another had a red coat with a white garment beneath, the vegetation being painted from nature out of doors in the sunlight, and this picture, which was now in the possession of Mrs. Coombe, at Oxford, had stood remarkably well. The way in which that was done was as follows: Each morning he put into a cup a portion of copal varnish, and an equal quantity of linseed oil, combining the two with a little rectified spirit of turpentine, and used it for his day's work. No doubt, microscopically, many defects might be found in the picture, but to the eye none were apparent. Pictures painted by Millais at the same time were painted at once on a white ground, as his were, and with copal or amber, and the picture from Keats at Liverpool was a marvel in its condition as to color and purity. With regard to the superiority of mastic for preserving paint, he thought it necessary to utter a word of caution, as many picture dealers were in the habit of giving a picture, if it was dull, a coat of varnish without any regard to how the picture was painted. If the picture was painted in one coat, as in the case of the Van Eyck, there was very little oil in the earths, and colors made from the juice of vegetables to protect them, and therefore, before having a coat of mastic, it was desirable that it should have a further coat of a mixture of resin varnish and oil.

Mr. Walter F. Reid said that he had made many experiments in the laboratory on this subject, but he had found it necessary at the commencement to take one line only; and the line which he took related chiefly to the vehicles, and not to the pigments. As to the remark about the Van Eyck, that the green had been produced by verdigris, he thought it was possible that it might be malachite, as he had lately come across an old recipe for grinding up and mixing the verdigris with powdered marble; the result of this mixture would practically be malachite. As to moisture, he thought the question arose whether the water might not be produced in the decomposition of the organic substance of the medium itself. It was highly probable that during the oxidation of the linseed oil water was formed, but this was a subject which might possibly form a subject for future experiment. In boiling linseed oil many peculiar substances had been mentioned which had to be added during the boiling, but the majority of these had no action whatever upon it. The oil was usually boiled with litharge and red lead, though he preferred a mixture of both, as this gave a perfect oil for all practical purposes. In refining the oil, if it was treated by mixing it with water, and exposing it to the air, in the sun, part of it was oxidized, the unoxidized oil, being heavier than water, would settle at the bottom, which was an important matter. Some of the old masters put the percentage of oil which was lost in the refining at from 50 to 70 per cent. The residue was not diluted with a fatty oil or drying oil, but with a volatile substance, such as oil of spike or oil of lavender. Having spent many hours in trying to solve the problem as to what were the distilled oils formerly used, he had come to the conclusion that in nearly every recipe for distilling oils mentioned by the old Italian and German writers, some substance was used which gave a volatile distillate; in some cases they either mixed mastic varnish or mastic itself, and in one case the painter recommended the mixing of linseed oil with sufficient lavender flowers to absorb it, and then to distill the mixture with water. It was probable, therefore, that some distilled oil which was used was not any product from the distillation of linseed oil itself, but from substances mixed with the oil in distilling. He did not agree with Mr. Laurie that a spirit varnish could be easily removed without injury to the picture, his own opinion being that it was very difficult to remove it without acting on the medium of the picture. As to the solubility of the colors in the medium, and the interaction of the colors, he thought this might be accounted for by the formation of certain salts which acted upon each other. Old writers dwelt on the importance of not using too much oil, and he thought in this respect they were correct. The difficulty with linseed oil was that up to the present its subsequent history was not known. Pettenkofer stated that dried oil was insoluble in water, spirits of wine, ether, oil of turpentine, and other liquids, and this was correct when the oil was fresh, but after a time a change took place in it upon being exposed to the air, and this change was of great importance to artists. After four or five years the surface of a piece of pure oxidized oil, either boiled or raw, became sticky, and after a lapse of ten years the whole of it was converted into a sticky substance which changed its qualities. In the first instance, oxidized linseed oil was insoluble in different substances, especially alcohol. If linseed oil at that age was treated with alcohol, it would be dissolved entirely. A new picture might be immersed in alcohol without its being injured, but an old picture would be destroyed. On the table were two specimens of oxidized oil, one being boiled linseed oil oxidized in 1878, the surface of which, after four or five years, began to get sticky and to run down, the other sample being raw linseed oil of the same age, which was perfectly oxidized. The first specimen had been boiled in the ordinary way with one half per cent. of litharge and a half per cent. of red lead. In the first oxidization of linseed oil there was a great increase in weight and bulk, the increase in weight being about 11 per cent., though he had not been able to tell the exact increase on the second oxidization. The consequence was there must be wrinkles on the oil, if the film was thick, owing to this increase in weight. The properties of the modified oxidized oil were of the greatest importance for the subsequent treatment of pictures; and Pettenkofer was not aware of this, as he distinctly stated that the oxidized oil was insoluble in alcohol, which was not correct. One might, perhaps, wonder why pictures were not sticky after a length of time, but the reason was, first, that the basis on which they were painted was porous, so that the liquid was absorbed by it, and the pigments themselves absorbed a great part of the semi-liquid products as they were produced; and, in the next place, they would combine with them, especially lead. This brought him to the consideration of the quantity of oil which artists used for different pigments: 100 parts by weight of white lead required 12 parts by weight of boiled linseed oil, 100 parts of zinc white required 14 parts of boiled linseed oil, 100 parts of chrome yellow required 19 parts of linseed oil, 100 parts of ivory black required 112 parts of oil, 100 parts of burnt sienna required 181 parts of oil, and 100 parts of raw sienna required 240 parts of oil. Dark colors required more oil, as they were not of a basic nature and did not combine with acids; consequently the oil, doubly oxidized, remained in its semi-liquid or liquid state unless the canvas absorbed it. As the results of experiments made with gums, he found that melted gums were not so fine as gums in their natural state. If you took a piece of copal and melted it, it would be found to be beautifully bright, but after a time it became covered with cracks, though the reasons for this have not been ascertained.

Professor Roberts-Austen, C.B., F.R.S., thought the author of the paper had made an extremely happy selection of a material to test the presence of moisture in anhydrous sulphate of copper. It was quite true they did not know much about thin films, though they knew more about thicker films. One might suppose that stretching a thin, transparent sheet of India rubber over a picture would protect it, but such was not the case, as carbonic anhydride and sulphurous acid would find their way through its surface. These gases, which were always present in a place like London, might lead to the permeation of water through the film. With regard to diffusion, it might not always be a question of diffusion of a crystalline pigment in a colloid salt, for solids could diffuse through solids; *e. g.*, if one floated a piece of pitch on water, and placed a cork beneath, the cork would find its way up through the pitch. The Japanese had been most successful in preserving the colors they employed beneath their lac; and he suggested that the nature of the lac used by them was well deserving of further examination. With regard to the formation of malachite, which had been referred to in the Van Eyck, he thought that the suggestion was quite probable.

Mr. John Hughes said he should be glad to have Mr. Laurie's opinion of a medium composed of equal parts of linseed oil, turpentine, and water. This medium formed a milky-like fluid, and was very nice to paint with.

The chairman said in his younger days he recollected a medium which was composed of linseed oil, water, and sugar of lead, to combine with which there might have been turpentine, but about this he was not quite certain. With regard to the green in the Van Eyck, he thought verdigris alone could not have been used, and that there must have been an admixture—an opaque pigment, possibly—of malachite to give solidity. If verdigris alone had been used over the yellow ground, there would not have been a solid color; it would have been filmy and stainy.

Mr. Laurie, in reply, said he thought the rate of change depended entirely on the external moisture, it being more rapid according to the way the experiment was performed. If done in an ordinary room it would be very slow, but if under a bell jar, with a saucer of water, it would go on very rapidly. With regard to refining oils, so far as his experience went, the bulk of the water was not very much affected; a considerable amount of white flocculent precipitate separated out, though it was a small proportion to the bulk of the oil. The oil got faint in color and the precipitation seemed to stop. He had not noticed the removal of a large quantity of oxidized oil, his aim being simply to get the oil to a pale color and to remove from it the gross impurities. In the case of the films he examined microscopically, his first idea was that solid particles were falling through the oil, but on examination he found no trace of this, so he came to the conclusion that it was more likely the color had been partially dissolved, and was diffusing as separate molecules than as actual particles. With reference to the verdigris in the Van Eyck, he was not able to say that it had not been mixed with other things. After what had been said, he thought the best thing artists could do would be to avoid the use of linseed oil altogether. In order to arrive at a definite conclusion upon the subject it was necessary that three people should work together, viz., the manufacturer of color, the artist, and the man of science. He was unable to answer the question put by Mr. Hughes, as he had no knowledge one way or the other of the medium named, though he could not imagine that any advantage would be gained by the admixture of the water.

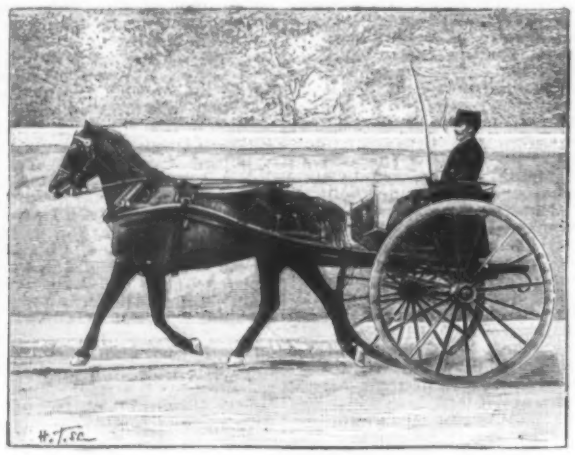
ALUMINUM is one of the most difficult and uncertain of metals to deposit electrolytically. The following recipe is given by Herman Reinbold, who states that it furnishes excellent results: Fifty parts by weight of alum are dissolved in 300 of water, and to this is added 10 parts of aluminum chloride. The solution is heated by 200° Fahr., and when cold 30 parts of cyanide of potassium are added. A feeble current should be used.

INSTANTANEOUS PHOTOGRAPHY.

WE give herewith a reproduction of an instantaneous photograph taken by Mr. Ottenheim, vice-president of the Versailles Photographic Society. It represents a gig to which is harnessed a horse going at a full trot. From the shadow of the legs it may be seen that the horse is in the air, and that none of his feet touches the ground. He was passing in front of the operator at a distance of about twenty feet when the photograph was taken.

This is a circumstance assuredly due to a fortuitous accident, but one that is of a nature to interest photographers.

We have often dwelt upon the curiosity of the remarks to be made apropos of the attitude of man or animals in instantaneous photographs, and we confine ourselves at present to the addition of one document more to those that we have before published.



INSTANTANEOUS PHOTOGRAPH OF A HORSE AT A FULL TROT.

The negative that served for obtaining the positive that we reproduce was taken with a small hand camera provided with a Balbreck objective, a $\frac{1}{8}$ inch diaphragm and an Ottenheim shutter.—*La Nature.*

NICEPHORE NIEPCE'S HOUSE.

THE accompanying engraving, reproduced from *La Nature*, represents the house in which Nicephore Niepce, one of the early investigators to whom we owe the modern art of photography, made his first discoveries. This house of humble appearance is situated near Chalon-sur-Saone, and is now on the line of the Paris-Lyons-Mediterranean Railway.

It was starting from 1811 that Niepce, after having had to separate from his brother Claude, began to reside near Chalon, in the house that our readers have before their eyes. It was here that the persevering investigator devoted ten years of his life to the pursuit of the problem that he was endeavoring to solve. After numerous labors in mechanics and in the practice of pastel drawing, Niepce branched off in a different direction at the time that lithography made its appearance in France. He made experiments in reproduction upon lithographic stones, and soon began to make use of plates of polished tin. He tried various varnishes of his own composition on these plates, then upon the latter he laid engravings that he had previously rendered transparent with varnish, and afterward exposed the whole to the light from the windows of his room. That was the beginning of heliography.

HOUSE OF NICEPHORE NIEPCE, NEAR CHALON-SUR-SAONE.

Once started in this direction, Niepce continued his researches unweariedly, and it was not long before he had recourse to the camera obscura. Isolated in his modest country house, he had to put his wits to work to manufacture for himself what he had need of. He made his own cameras and his own apparatus. In 1817, for his heliographic studies (as he called them), he had recourse to chloride of silver, then to organic materials (such as guaicum resin), and finally to phosphorus, which, at first white, gradually reddens in contact with light; but this latter dangerous substance he soon abandoned. It was in 1826 that he fixed definitely upon bitumen, a resinous material which, spread out in a thin stratum and submitted to the action of light, becomes notably lighter in color. During the following year, Daguerre, who on his side was experimenting on the fixation of images in the camera obscura, entered into correspondence with Niepce, and the two investigators became associated; and when we wish to speak of the inventors of modern photography, we should write the names of these two men side by side.

PHOTO-ELECTRICITY.

PROF. G. M. Minchin, M.A., read a paper before the Physical Society, January 16, 1891. His experiments on the subject were commenced in 1877, in attempting to produce a photographic image of a distant object. The result sought for has not hitherto been obtained, but the experiments have led to the discovery of many interesting phenomena. Some of these were shown to the meeting.

Electric currents are produced by the action of light on silver plates coated with collodion or gelatin emulsions of bromide, chloride, iodide, and other silver salts, or with eosine, fluorescine, and other aniline dyes, when the plates are immersed in a suitable liquid, and one plate is illuminated while the other is screened. The direction of the currents depends on the materials employed, and the blue end of the spectrum is most effective. Currents have a photographic effect on the plates, and this action is strictly confined to the parts through which the current has passed.

Comparatively strong currents are obtained from plates coated with eosine and gelatin. A curious reversal was observed with some cells, the exposed plate first being positive to the screened one, and almost immediately afterward became negative. On shutting off the light, a transient increase of current resulted, and afterward disappeared gradually.

M. Becquerel, who has studied the action of silver plates coated with bromide, etc., concludes that the nature of the exposed plate (whether positive or negative) depends on the thickness of the surface layer. The electromotive force of such cells rarely exceeds one-twentieth of a volt.

Uncleaned tinfoil plates in common tap water give a current when one is exposed to light and the other screened. Cleaning the plates destroys the effect. In nearly every case the exposed plate was first positive and after a time became negative; and by exposing various parts of a plate (some portions of which had been previously exposed) the currents could be varied in direction at will. These peculiarities may explain the known divergence of tin from Volta's law. The phenomena have also been studied by aid of the electrometer. Tinfoil obtained from tobacco packages was found to be very sensitive to light. One side of such foil is dull and the other bright. By pasting slips of it on opposite sides of a glass plate so that dissimilar sides are outermost, and immersing them in alcohol, a cell giving an E.M.F. of one-sixteenth volt when the dull side was exposed to light was obtained. The addition of any salt to the liquid, with a view to diminishing the resistance, invariably reduced the E.M.F. Experiment showed that the alcohols were by far the best liquids to use with tin plates.

A process for producing very sensitive tin plates was described, which apparently results in the formation of white oxide of tin on the surface of the foil. With one such plate and another sensitized plate the best results have been obtained by immersing them in methyl alcohol prepared from oil of wintergreen. From experiments on the variation of E.M.F with intensity of light, it was found that the square of the E.M.F. is proportional to the intensity.

Some tin cells behave in a very peculiar manner, for it often happens that a good cell will exhibit no E.M.F. after being kept a few days. A slight impulse or tap given to the cell or its support restores the sensitiveness; another impulse makes the cell insensitive; and these effects can be repeated indefinitely. Such cells the author calls "impulsion cells," and some were exhibited at the meeting. The sensitized plate of one of these cells had different properties at its two ends, for impulses had no effect on the nature of the lower end, but changed the upper end from positive to negative, and *vice versa*. Electro-magnetic impulses, such as produced by sparks, are capable of altering cells from the insensitive to the sensitive state, but fail to produce the reverse effect. A Hertz oscillator restored the sensitive state in a cell placed at a distance of 81 feet away. The "impulsion effects" can be got rid of by renewing the alcohol on several successive days.

During last year the author made some selenium cells by spreading the melted substance on metal plates and immersing them in liquids together with an uncoated plate. Of the various metals and liquids tried, aluminum and acetone gave the best effects. The process of forming these "seleno-aluminum cells" was described. One of their peculiarities is that they are nearly equally sensitive to rays of all colors, and when exposed to strong light may give an E.M.F. of $\frac{1}{10}$ to $\frac{2}{3}$ of a volt, the sensitized plate being negative. An arrangement of 50 cells in series, with an electrometer, was exhibited, whereby the E.M.F. generated by light falling on the cells could be caused to ring a bell, light or extinguish electric lamps, etc.

THE INVENTORS OF THE TELEGRAPH AND TELEPHONE.*

By Prof. THOMAS GRAY.

TO telegraph means literally to write at a distance, but that is not the popular meaning of the term. When we speak of a system of telegraphy, we have usually in mind simply a systematic method of conveying intelligence to a distance. Taken in this sense, there are a large number of different kinds of telegraphs, such as hydraulic, pneumatic, wire, flag, semaphore, trumpet call, gun fire, flash light, beacon fire, etc., etc., besides the one which is now usually associated with the name, the electric telegraph. Any means of conveying intelligence to a distance which the human voice will not reach is spoken of as a telegraph.

One of the earliest systems of telegraphy was introduced about the middle of the seventeenth century by order of the Duke of York (afterward James II. of England), then Admiral of the English fleet. This was the beginning of the flag telegraph, almost universally used between ships at sea, and was originated for the purpose of directing the movements of the fleet. In 1694 Dr. Hooke proposed to telegraph by means of objects of different shapes hung on high poles. A century later the semaphore of M. Chappe was adopted by the French government for the same purpose.

Generally speaking, these early forms of telegraphy, of which there were quite a number of kinds used, were adopted and perfected during time of war. Undoubtedly war has been a large factor in furthering the development of our modern telegraphs, and in this way at least may be said to push forward the march of civilization. Some of these forms of telegraph are still used, as, for example, the semaphore for railway signals, the bell worked by wire for communication between the bridge and engine room in steamships, and flag signals for communication between ships at sea. The chief interest of these early forms, however, in connection with our present subject, is an illustration of the importance which telegraphy has at all times been recognized to have. The telegraph of to-day is almost entirely electrical and, in its present form, it is of comparatively recent growth. It may, however, be well to glance very briefly at the early attempts which were made to use electricity for this purpose, and to note how persistently the possibility of making this application was brought forward as each distinct advance was made in the science of electricity and magnetism.

In the year 1617 we find an allusion in one of Strada's "Prolusions Academicæ" to the belief that there existed a sympathy between needles which had been touched by a species of loadstone, which, when they were freely pivoted, caused them to set in the same direction. Thus, he says, two of the needles may be used to convey intelligence to any distance instantaneously, because if they be mounted on a card marked with letters and are turned so as to point to any letter the other will immediately do so also. Again, in 1632, Galileo, in one of his dialogues, puts in the mouth of one of the speakers a reference to a secret art by means of which, through the sympathy of magnetic needles, it is possible to converse through a distance of several thousand miles. A similar suggestion is made by the Abbe Barthelemy, published in 1788, entitled "Voyage du Jeune Anacharsis." So far this may be said to be mere fable, as it is hardly possible to believe that such a proposal would even then be made in good faith. They bring out, however, what may be looked upon as an indication of the popular idea at that time as to the possibilities of magnetism. We have occasionally at the present day propositions as to the powers of electricity which are equally ideal.

The discovery of Stephen Gray in 1729 that the electrical influence produced by friction could be transmitted to a distance through a "non electric" material is probably the first of direct interest in connection with telegraphy. We have, as a result of this discovery, the proposal, in 1753, of a telegraph by Charles Morrison, of Renfrew, Scotland, in which a number of separate conductors were to be used for the purpose of spelling out the message by putting them in contact with balls placed over letters printed on light material which could be lifted by the electrified balls. Several modifications were proposed, and are of considerable

* A paper read at the Centennial Celebration of the Establishment of the American Patent System.

interest; mainly, the possibility of causing the electrified balls by their attraction to ring bells and thus give an acoustic telegraph. A similar system was proposed by Joseph Bozolas, a Jesuit priest, in the year 1767, and seven years later Lesage modified the idea by the proposal to use pith ball electroscopes to indicate the signals.

This telegraph was actually constructed on an experimental scale. In 1787 Lomond simplified the pith ball telegraph to one wire and one electroscope by means of which he was able to keep up a conversation with his wife in a distant apartment of the house. To Lomond then appears to be due the first proposal to use an alphabet of motions. A similar one-line telegraph was proposed in the same year by Betancheourt. An ingenious idea was proposed in 1794 by Rousser, who used 26 wires, each wire being connected to a strip of tinfoil, small breaks in which formed a letter. The letter was to be made visible by an electric spark. The illumination of patterns in this way has continued to be a favorite class room illustration to the present day.

In the following year we find another proposal of an alphabet of signals, made in this case by M. Cavallo. One wire was to be used, and the alphabet was to be made up of sparks and pauses in various combinations. Cavallo also proposed to use an alarm to call attention. This was to consist of an explosion of a mixture of oxygen and hydrogen, or of gunpowder by means of the electric spark. Another proposition of a similar character, but of which the particulars seem to be unknown, was proposed by Salva in 1796. After this there appears to be no record of the application of frictional electricity to telegraphic purposes till 1816, when Ronalds' experiments were made at Hammersmith. In this telegraph two clocks were used in conjunction with one line wire and a pith ball electroscope at each end. On the second hand arbor of each clock a light dial was placed on which the letters of the alphabet were printed. A screen was placed in front of the dial, through a hole in which the letters could be seen. At a time when the proper letter came in front of the screen at the sending end, a signal was sent, and the letter opposite the hole in the screen at the receiving end was then read.

It will be observed that a considerable amount of energy was spent on the electric telegraph, and some very feasible methods were proposed before electrical science had passed the stage of the frictional generation of electrical force.

In the year 1767 an important observation was made. It was noticed that when a plate of one metal was placed on one side of the tongue, and a plate of another metal was placed on the other, a curious sensation was felt when the metals were allowed to touch outside the tongue. The observer failed to find the explanation, and nothing more was done until the well-known experiments of Galvani gave an impetus to the subject, which resulted in the discovery of the galvanic or voltaic pile by Volta. Shortly afterward an attempt to close the circuit of a voltaic pile by a drop of water led Nicholson and Carlisle to the discovery that the galvanic current decomposed water. Here was a new means of giving signals, and eight years later we find a proposal by Sommering to make use of the evolution of gas in a series of tubes connected to a distant station by means of conduction wires for the transmission of intelligence. A call signal was to be obtained by causing the liberation of gas to operate an alarm. A similar idea to that of Sommering suggested itself about the same time to Prof. Coxe, of Pennsylvania, who, however, seems not to have worked it out to any extent. The next important discovery which influenced telegraphy was made by Romagnosi, of Trent, in 1805, but does not seem to have become widely known until rediscovered by Oersted, of Copenhagen, in 1819. This discovery was the deflection of the magnetic needle when a wire conveying a current was brought near it, the wire being approximately parallel to the length of the needle. In 1820 Schweigger discovered that if the wire be bent round the needle several times, the force with which the needle is deflected is increased. These two discoveries formed the foundation for the galvanometers since so much used in electrical appliances and measurements. One of the most extensive applications has been to telegraphy.

Ampere in 1820 was the first to point out the application of the galvanoscope and voltaic battery to telegraphy, but proposed to use as many wires as letters or signs to be transmitted. A modification of this invention was made by Ritchie, who constructed an experimental telegraph, in which the letters of the alphabet were arranged behind a set of light screens, which were drawn aside by the current, thus exposing the letters to view. This telegraph was exhibited some years later by Mr. Alexander, of Edinburgh, and consisted of a keyboard of 30 keys representing 26 letters, three punctuation marks, and an asterisk for indicating the end of a word. These keys were connected to as many wires operating screens as above described. The return current was common to all.

In 1832 Schilling invented his five-needle telegraph, which was subsequently modified to a single needle. Two wires were used and an alphabet of motions made use of, much in the same way as is still carried out by the single needle system. A telegraph on Schilling's plan was used in the following year by Gauss and Weber in connection with their electrical researches and the regulation of clocks. Schilling, however, died before any practical development of the telegraph was made. It seems probable, however, that the idea of the needle telegraph, so long used successfully in Europe, and particularly in England by Cooke and Wheatstone, was devised by Schilling.

Steinheil was the next to enter the field of telegraphic invention, and he appears to have done so at the suggestion of Gauss, who saw great possibilities of it development. Steinheil invented his telegraph in 1837. He constructed a line several miles in length at Munich and fitted it with recording apparatus of an ingenious kind. A flat coil or multiplier was made, and inside the coil two magnetic needles were fixed so as to form continuations of each other, one end of each being at the center of the coil. These magnets carried at their central ends recording pens. A band of paper was carried past these pens, and the record was obtained by causing the pens to strike the paper and leave dots at the point of contact. Reverse currents were used, one pen answering to a current in one direction and the other to currents in the other direction. The system practically amounted to a double needle system worked by one circuit and one galvanoscope.

The telegraphs of Gauss and Weber, and the developments of them by Steinheil, have special interest, from the fact that they were the first telegraphs which used what we now call induced currents. The currents were produced by the relative motion of a coil of wire and a magnet. This was an application of the discovery of Faraday and Henry, that the motion of a magnet in the neighborhood of a circuit produced transient currents in the circuit, a discovery which has had wonderful effects in the development of modern dynamo-electric appliances.

Another discovery of great importance and interest, which we owe to Steinheil, is the earth circuit. While experimenting with a view of using the rail of a railway as one of the wires of his circuit, he discovered that the earth itself might be used for one half of the circuit, and he removed one of his wires, substituting plates buried in the earth. This method is still practiced, and the discovery has proved one of the very greatest importance.

Previous to the date which we have now reached another epoch-making discovery had been made in electricity and magnetism. This was the magnetizing influence of the current. The discovery of Oersted was followed up by Ampere in a long series of experiments, in the course of which he found the mutual attraction and repulsion of wires carrying currents; the fact that the voltaic element itself acted as a magnet like any other part of the circuit, and also that a spiral part of a circuit would magnetize steel needles. M. Arago also in the same year discovered that the wire conveying the current attracted iron filings in much the same way as a magnet does. In 1824 Barlow investigated the law of variation of the magnetic force at different distances from the wire. In 1825 Sturgeon discovered that when a bar of soft iron is surrounded by a helix, and a current is sent through the helix, it is temporarily magnetized. We see from these leading facts that in the twelve years preceding Oersted's discovery progress in the knowledge of electricity and electro-magnetism in the directions important for telegraphic application was very great, and we shall see that this knowledge very quickly bore fruit.

A copy of Schilling's telegraphic apparatus, exhibited by Prof. Muncke at Heidelberg, in 1836, gave the idea of the electric telegraph to Cooke. Cooke immediately set to work to construct a telegraph on a similar plan, and worked out several schemes which he had partially succeeded in introducing on the railway systems of England. Through some difficulty with an electro-magnetic arrangement he was led to consult Prof. Wheatstone, and a partnership soon followed, which led the latter to devote considerable attention to the subject. The result has been the production of a large variety of apparatus of great value and ingenuity.

The first to prepare a recording telegraph seems to have been Prof. Morse, of New York. This invention dates back to 1832, according to a considerable amount of evidence brought forward by Morse, and a rough model existed as early as 1835. In this telegraph an electro-magnet is used as the motive force, and Morse claimed not only the first recording telegraph, but also the first application of the electro-magnet in telegraphing. There can be no doubt, however, but that the credit of having first used the electro-magnet for telegraphic purposes is due to Prof. Henry, then a teacher in the Albany Academy. To Prof. Henry belongs not only the credit of using the electro-magnet for this purpose, but also that of having developed the discovery of Sturgeon to such an extent as to enable any one to make a magnet which would be of service as a receiver on a long telegraph line.

Another important invention in this connection has to be given to Henry. While experimenting on the electro-magnet he turned his attention to the construction of the electro-magnetic engine, and in connection with it contrived a method of closing the circuit of the engine from a distance by means of an auxiliary circuit and an electro-magnet. This is the electro-magnetic relay, afterward reinvented by Morse, and now used on nearly all important telegraph circuits. We see, therefore, that the credit of the application of the electro-maguet to telegraphic purposes was of American origin, but that it was not first, as is popularly believed, made by Morse. The conception, however, of a telegraph by Morse, whether it originated with him or not, has proved of great value. He, in conjunction with Vail, worked it out on a practical scale, perfected details, invented the Morse alphabet, and last, though not least, succeeded after a great amount of trouble and many disappointments in obtaining the support of Congress toward making it a national enterprise. Previous to the year 1842, when Congress passed an appropriation for experiments with the electric telegraph, the application of electricity to this purpose had gone practically beyond the experimental stage in Europe, the single and double instruments being used for indicating the signals. It has been long popularly believed in this country that Morse invented the electric telegraph. In the same way it was long popularly believed in England that Wheatstone did so, and similarly in other countries. It will be seen, however, from the brief sketch here given, that the invention of the electric telegraph does not belong to any one man or any one country. It has grown with scientific knowledge, and forms, as it stands to-day, one of the best illustrations we have of the value of purely experimental investigations.

From this time until the question of using one wire for more than one message at one time and the problems of submarine telegraphy arose, no new scientific principle was required. Methods of recording and indicating signals multiplied, and mechanical contrivances of great beauty were invented for many of these, but the discoveries of Volta, of Oersted and Schwiegger, of Nicholson and Carlisle, of Sturgeon and of Faraday and Henry were enough, from the electrical standpoint, for them all. Of the different methods which were invented in the next quarter of the century, we may take the chemical telegraphs of Davy, Bain and others; the dial telegraph of Wheatstone, Breguet, Froment, Siemens, Chester, Koemer; the automatic telegraphs of Bain, Siemens and Halske, Garnier, Humaston, Wheatstone; the copying telegraphs of Bakewell and the pantelegraph of Casselli; and the type printing telegraphs of Vail, Wheatstone, House and Hughes. In more recent times many of these inventors and a host of others, including in this country the names of Bell, Calahan, Delany, Edison, Gray, Laws, Little, Park, Phelps, Prescott, Smith, Stearns and many more, have added important contributions to the subject. The type printing instruments produced by several of these inventors are triumphs of mechanical ingenuity which find few equals in any branch of mechanical industry.

As distinct from the instrumental improvement in telegraphy, the next important advance was multiple transmission. A solution of the problem of transmitting simultaneously from both ends of the same line wire was first attempted in 1853 by Ginti, of Vienna, and again by Frischen and Siemens and Halske. The solutions proposed by these inventors were mechanically sufficient for the purpose, but they overlooked an important factor which had not before been considered important in land line telegraphs—the electrostatic capacity of the line. The difficulty was first successfully overcome by Stearns, of Boston, at the close of 1871, and since that time duplex working has become quite common. The application of Stearns' method to submarine telegraphs involved peculiar difficulties, on account of the very large capacity of the line, and, in the more important cables, the great length of the circuit. The credit of having completely overcome these difficulties for submarine cables is mainly due to Dr. Muirhead, of London. The chief workers in this field were: Gentl, Frischen, Siemens and Halske, Preece, Farmer, Nystrom, Maron, Winter, Stearns and Muirhead. The problem of how to send two messages in the same direction being solved, the transmission of four messages simultaneously over the same wires was attacked. This was first proposed by Stark, of Vienna, in 1855, and subsequently worked at by Boescha, Kramer, Mason, Schaak and others. To first to obtain satisfactory results was Edison, who invented his method in 1874. Successful systems of quadruplex have since been invented by Smith and Prescott jointly.

Another system of multiple transmission was proposed by Moses G. Farmer, of Salem, Mass., in 1852, in which, by a commutating arrangement, the main line wire was put, in rapid succession, in contact with a series of branch wires, by proper connection at the sending station and two communicators worked in unison. It was then proposed to divide the transmitting capacity of the main line wire among a number of branch wires, so that the messages might go over all of these at the same time. A similar arrangement was proposed by Meyer, and shown in operation at the Vienna exhibition in 1873. The same principle is adopted in Delany's telegraph, devised a few years ago and in successful operation in various parts of the world.

Distinct from these is the harmonic telegraph of Gray, Edison and Bell. In this system, which has been completely worked out by Gray, any number of messages may be sent simultaneously without reference to speed of transmission. In principle the method consists in causing a number of vibrating reeds of different pitch at one end to produce vibrations in a corresponding set of reeds at the other end of the line, each of the receiving reeds picking out the vibration which has the same pitch as that of its own vibration.

Although the mere extension of telegraphs from land to submarine lines can hardly be called an invention, yet very many new problems presented themselves for solution in this extension. Many of these problems were of a more scientific character than those presented in the developments which had been in progress, and consequently taxed the knowledge then existing of the laws of electricity much more severely. It was very soon discovered, for example, that the rate at which signals would be transmitted and the battery power, or other electromotive power necessary to effect the transmission, did not, as in land lines, depend almost entirely on the size of and length of the conductor. The electrostatic capacity of the line immediately began to play an important part, and signals were found not to be so instantaneously transmitted as they were on existing lines. Again, there was no opportunity of using relays so as to effectually shorten the longer lines.

Such difficulties as these, combined with the very evident mechanical difficulties of manufacturing and submerging a cable in deep water, were, to say the least, discouraging. Experiments in short lengths in the English Channel and elsewhere proving successful, faith in the possibility of longer cables grew, and very soon, through the enterprise of a few American and English business men, an attempt was made to lay a cable across the Atlantic. The history of that undertaking and its various failures are almost common knowledge, but perseverance conquered all the difficulties, and to-day very little is thought of difficulty when a long cable is proposed.

The laying of long cables brought out the fact that, as had been anticipated, existing telegraphic apparatus was not of great enough sensibility to render rapid signaling possible. This difficulty was almost immediately met by the mirror galvanoscopic receiver of Thomson, followed some years later by his siphon recorder, which is undoubtedly by far the most sensitive recording telegraph known. Improvements in methods of working cables soon followed, among which in the early days probably the most notable is the introduction of condensers between the ends of the cable and the earth by Varley. The duplexing of cables has already been referred to, but it is somewhat curious to note that, although the electricians interested in cables were familiar as early as 1856, and perhaps earlier, with the difficulties which had prevented success on land lines, no one seems to have thought of applying the remedy. As early as 1858 a patent was taken out by Thomson, in which he proposed to overcome this difficulty of duplexing a cable by a mechanical arrangement for varying the compensating currents at the same rate that the signaling current varies. He has since said that he did not propose the use of condensers, because a means of producing a sufficiently good cable was not then known.

The invention of the telephone constitutes one of the greatest advances that have been made in telegraphic communication. This is an acoustic telegraph which has the very important merit that the audible signals are spoken words, and hence the instruments can be used by any one who can hear and speak.

It is well known that sound is transmitted through

the air from speaker to hearer by means of waves, condensation and rarefaction, which affect the drum of the ear. Wheatstone, as early as 1831, showed that these waves could be transmitted from one place to another at a moderate distance through wooden rods, and afterward conveyed to the ear by the vibrations given to the air by the end of the rod. Similarly, vibrations given to one diaphragm to produce the corresponding vibrations in another diaphragm at a distance by means of electric currents was the problem of the electric telephone. The first to propose this appears to have been Charles Bourseul, who, in 1854, suggested the use of two plates, one at the transmitting station, which, by the varying pressure of the air due to the sound waves, would open and close an electric circuit, while the other was to be acted on at the receiving station by an electromagnet, through which the electric currents passed.

In 1861 Philip Reis, of Friedrichsdorf, proposed in a lecture delivered before the Physical Society of Frankfort, to use an instrument which he called a telephone, for the production at a distance of music and human speech. The apparatus consisted of a flexible membrane, forming one side of a box, with which, by means of a mouthpiece, the sounds could be directed. This instrument was made to open and close an electric circuit at each vibration. At the receiving end an electromagnet consisting of a thin rod of iron surrounded by a coil was placed. The successive interruption and closing of the electric circuits was in accordance with a discovery made by Dr. Page, of Salem, Mass., in 1837. This method could not be successful for speaking for the simple reason that speech has more characteristics than pitch, and was only partially successful for musical sounds. To produce not only corresponding vibrations, but also loudness and quality of the sounds, evidently required a transmitter and receiver which did not depend for its action on such interruptions of the current, but which varied the current in a pulsatory manner similar to the variations of pressure on the diaphragm due to the waves.

Such an apparatus of a very perfect type was produced by Graham Bell in 1876, who, in the description of his apparatus given in his patents and elsewhere, shows that he thoroughly understood what had to be done. We all know that the instrument which he produced did it. Since the publication of Bell's invention a great many modifications have been produced. Most of them, however, have been held to be similar in principle to Bell's. One field of investigation has, however, been fruitful of improvement. In the original patent of Bell, and in a caveat filed almost simultaneously by Gray, it is pointed out that the variations of the current may be produced by causing the vibrations of the diaphragm to vary the resistance of the circuits. This idea has proved of great value in increasing the loudness of the sounds given out by the Bell telephone used as a receiver. A great many forms of these "microphone" transmitters have been invented. Among those who have made important contributions to this subject we may mention Berliner, Edison, Gray, Blake, Gower and Hunning.

Another form of telephone has been proposed by Prof. Dolbear. In this telephone system one diaphragm of the receiver is made to form one plate of an electric condenser, and the varying force on this plate due to the fluctuations of the charge causes it to vibrate in response to the varying electro-motive force produced by the transmitter. This condenser telephone can evidently be used either as a transmitter or receiver.

Another interesting discovery in this subject should be mentioned, namely, the transmission of speech from one place to another by variations in a beam of radiant heat or light. This is based on the discovery of the variation of the electric resistance of selenium when exposed to light or radiant heat. The experiments of Bell and Sumner Tainter have shown that, if a beam of light be reflected from a mirror to a bar of selenium which is in the circuit of a telephone and battery, the telephone will repeat words spoken to the mirror.

SUMMARY OF USEFUL TESTS WITH THE BLOWPIPE.*

By A. J. MOSES.

THE following selection includes only the tests used in the instruction at the Mineralogical Laboratory of the School of Mines. It is believed that the omitted tests have always been omitted for cause, either as less characteristic or less easily obtained, or from the need of some unusual or not easily handled reagent.

The details of ordinary manipulations, such as obtaining beads, flames, coatings, and sublimates, are omitted, and the results alone stated; unusual manipulations are described. The bead tests are supposed to be obtained with oxides; the other tests are, in general, true of all compounds not expressly excluded. The course to be followed in the case of interfering elements is briefly stated.†

ALUMINUM, Al.

With Soda.—Swells and forms an infusible compound.
With Borax or S. Ph.—Clear or cloudy, never opaque.
With Cobalt Solution.—Fine blue when cold.‡

AMMONIUM, NH_4.

In Closed Tube.—Evolution of gas with the characteristic odor. Soda or lime assists the reaction. The gas turns red litmus paper blue, and forms white clouds with HCl vapor.

ANTIMONY, Sb.

On Coal, R. F.§—Volatile white coat, bluish in thin layers, continues to form after cessation of blast.
With Bismuth Flux—
On Plaster.—Orange red coat, made orange by $(NH_4)_2S$.
On Coal.—Faint yellow or red coat.
In Open Tube.—Dense, white, non-volatile, amorphous sublimate. The sulphide, too rapidly heated, will yield spots of red.
In Closed Tube.—The oxide will yield a white fusible sublimate of needle crystals, the sulphide a black sublimate red when cold.
Flame.—Pale yellow green.
With S. Ph.—Dissolved by O. F. and treated on coal with tin in R. F. becomes gray to black.

Interfering Elements.

Arsenic.—Remove by gentle O. F. on coal.
Arsenic with Sulphur.—Remove by gently heating in closed tube.
Copper.—The S. Ph. bead with tin in R. F. may be momentarily red, but will blacken.
Lead or Bismuth.—Retard formation of their coats by intermittent blast, or by boracic acid. Confirm coat by flame, not by S. Ph.

ARSENIC, As.

On Smoked Plaster.—White coat of octahedral crystals.
On Coal.—Very volatile white coat and strong garlic odor. The oxide and sulphide should be mixed with soda.
With Bismuth Flux—
On Plaster.—Reddish orange coat made yellow by $(NH_4)_2S$.
On Coal.—Faint yellow coat.
In Open Tube.—White sublimate of octahedral crystals. Too high heat may form brown suboxide or red or yellow sulphide.
In Closed Tube.—May obtain white oxide, yellow or red sulphide, or black mirror of metal.
Flame.—Pale azure blue.

Interfering Elements.

Antimony.—Heat in closed tube with soda and charcoal, treat resulting mirror in O. F. for odor.
Cobalt or Nickel.—Fuse in O. F. with lead and recognize by odor.
Sulphur.—(*a*) Red to yellow sublimate of sulphide of arsenic in closed tube. (*b*) Odor when fused with soda on coal.

BARIUM, Ba.

On Coal with Soda.—Fuses and sinks into the coal.
Flame.—Yellowish green improved by moistening with HCl.
With Borax or S. Ph.—Clear and colorless, can be framed opaque white.

BISMUTH, Bi.

On Coal.—In either, flame is reduced to brittle metal and yields a volatile coat, dark orange yellow hot, lemon yellow cold, with yellowish white border.
*With Bismuth Flux**—
On Plaster.—Bright scarlet coat surrounded by chocolate brown, with sometimes a reddish border. The brown may be made red by ammonia.†
On Coal.—Bright red coat with sometimes an inner fringe of yellow.
With S. Ph.—Dissolved by O. F. and treated on coal with tin in R. F. is colorless hot, but blackish gray and opaque cold.

Interfering Elements.

Antimony.—Treat on coal with boracic acid, and treat the resulting slag on plaster with bismuth flux.
Lead.—Dissolve coat in S. Ph. as above.

BORON, B.

All borates intumesce and fuse to a bead.
Flame.—Yellowish green. May be assisted by—(*a*) Moistening with H_2SO_4; (*b*) Mixing to paste with water and boracic acid flux (4½ pts. $KHSO_4$, 1 pt. CaF_2); (*c*) By mixing to paste with H_2SO_4 and NH_4F.

BROMINE, Br.

With S. Ph. saturated with CuO.—Treated at tip of blue flame, the bead will be surrounded by greenish blue flame.
In Matrass with $KHSO_4$.—Brown choking vapor.

Interfering Elements.

Silver.—The bromide melts in $KHSO_4$ and forms a blood-red globule which cools yellow and becomes green in the sunlight.

CADMIUM, Cd.

On Coal, R. F.—Dark brown coat, greenish yellow in thin layers. Beyond the coat, at first part of operation, the coal shows a variegated tarnish.
On Smoked Plaster with Bismuth Flux.—White coat made orange by $(NH_4)_2S$.
With Borax or S. Ph.—O. F. clear yellow hot, colorless cold, can be flamed milk-white. The hot bead touched to $Na_2S_2O_3$ becomes yellow.
R. F. becomes slowly colorless.

Interfering Elements.

Lead, Bismuth, Zinc.—Collect the coat, mix with charcoal dust, and heat gently in a closed tube. Cadmium will yield either a reddish brown ring or a metallic mirror. Before collecting coat, treat it with O. F. to remove arsenic.

CALCIUM, Ca.

On Coal with Soda.—Insoluble and not absorbed by the coal.
Flame.—Yellowish red, improved by moistening with HCl.
With Borax or S. Ph.—Clear and colorless, can be flamed opaque.

CARBONIC ACID, CO_2.

With Nitric Acid.—Heat with water and then with dilute acid. CO_2 will be set free with effervescence. The escaping gas will render lime water turbid.
With Borax or S. Ph.—After the flux has been fused to a clear bead, the addition of a carbonate will cause effervescence during further fusion.

CHLORINE, Cl.

With S. Ph. saturated with CuO.—Treated at tip of blue flame, the bead will be surrounded by an intense azure blue flame.
On Coal with CuO.—Grind with a drop of H_2SO_4, spread the paste on coal, dry gently in O. F., and treat with blue flame, which will be colored greenish blue and then azure blue.

CHROMIUM, Cr.

With Borax or S. Ph.—O. F. reddish hot, fine yellow-green cold.
R. F. in borax, green hot and cold. In S. Ph., red hot, green cold.
With Soda.—O. F., dark yellow hot, opaque and light yellow cold.
R. F. opaque and yellowish green cold.

Interfering Elements.

Manganese.—The soda bead in O. F. will be bright yellowish green.

COBALT, Co.

On Coal R. F.—The oxide becomes magnetic metal. The solution in HCl will be rose red, but on evaporation will be blue.
With Borax or S. Ph.—Pure blue in either flame.

Interfering Elements.

Arsenic.—Roast and scorify with successive additions of borax. There may be, in order given: Yellow (iron), green (iron and cobalt), blue (cobalt), reddish brown (nickel), green (nickel and copper), blue (copper).
Copper and other Elements which Color Strongly.—Fuse with borax and lead on coal in R. F. The borax on platinum wire in O. F. will show the cobalt, except when obscured by much iron or chromium.
Iron, Nickel, or Chromium.—Fuse in R. F. with a little metallic arsenic, then treat as an arsenide.
Sulphur of Selenium.—Roast and scorify with borax, as before described.

COPPER, Cu.

On Coal R. F.—Formation of red malleable metal.
**Flame.*—Emerald green or azure blue, according to compound.
The azure blue flame may be obtained—
(*a*) By moistening with HCl or aqua regia, drying gently in O. F., and heating strongly in R. F.
(*b*) By saturating S. Ph. bead with substance, adding common salt, and treating with blue flame.
With Borax† or S. Ph.—O. F., green hot, blue or greenish blue cold.
R. F. greenish or colorless hot, opaque and brownish red cold. With tin on coal this reaction is more delicate.

Interfering Elements.

‡*General Method.*—Roast thoroughly, treat with borax on coal in strong R. F., and—
If Button Forms, separate the button from the slag, remove any lead from it by O. F., and make either S. Ph. or flame test upon residual button.
If no Visible Button Forms, add test lead to the borax fusion, continue the reduction, separate the button, and treat as in next test (lead alloy).
Lead or Bismuth Alloys.—Treat with frequently changed boracic acid in strong R. F., noting the appearance of slag and residual button.
Trace.—A red spot in the slag.
Over One Per Cent.—The residual button will be bluish green when melted, will dissolve in the slag and color it red upon application of the O. F., or may be removed from the slag and be submitted to either the S. Ph. or the flame test.

FLUORINE, F.

Etching Test.—If fluorine is released, it will corrode glass in cloudy patches, and in presence of silica there will be a deposit on the glass. According to the refractoriness of the compound, the fluorine may be released—
(*a*) In closed tube by heat.
(*b*) In closed tube by heat and $KHSO_4$.
(*c*) In open tube by heat and glass of S. Ph.
With Conc. H_2SO_4 and SiO_2.—If heated and the fumes condensed by a drop of water upon a platinum wire, a film of silicic acid will form upon the water.

IODINE, I.

With S. Ph. saturated with CuO.—Treated at the tip of the blue flame, the bead is surrounded by an intense emerald green flame.
In Matrass with $KHSO_4$.—Violet choking vapor and brown sublimate.
In Open Tube with Equal Parts Bismuth Oxide, Sulphur, and Soda.—A brick red sublimate.
With Starch Paper.—The vapor turns the paper dark purple.

Interfering Elements.

Silver.—The iodide melts in $KHSO_4$ to a dark red globule, yellow on cooling, and unchanged by sunlight.

IRON, Fe.

On Coal.—R. F. Many compounds become magnetic. Soda assists the reaction.
§ *With Borax.*—O. F., yellow to red hot, colorless to yellow cold.
R. F., bottle green. With tin on coal, vitriol green.
With S. Ph.—O. F., yellow to red hot, greenish while cooling, colorless to yellow cold.
State of the Iron.—A borax bead blue from CuO is made red by FeO and greenish by Fe_2O_3.

Interfering Elements.

Chromium.—Fuse with nitrate and carbonate of soda on platinum, dissolve in water, and test residue for iron.
Cobalt.—By dilution the blue of cobalt in borax may often be lost before the yellow of iron.
Copper.—May be removed from borax bead by fusion with lead on coal in R. F.
Manganese.—(*a*) May be faded from borax bead by treatment with tin on coal in R. F. (*b*) May be faded from S. Ph. bead by R. F.
Nickel.—May be faded from borax bead by R. F.

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* From the *School of Mines Quarterly*, vol. xi., No. 1.

† *School of Mines Quarterly*, vol. viii., p. 229, and vol. x., p. 321.

‡ Certain phosphates, borates, and fusible silicates become blue in absence of alumina.

§ This coat may be further tested by S. Ph. or flame.

* Sulphur two parts, potassic iodide one part, potassic bisulphate one part.

† May be obtained by heating S. Ph. on the assay.

* Sulphur, selenium, and arsenic should be removed by roasting. Lead necessitates a gentle heat.

† By repeated slow oxidation and reduction a borax bead becomes ruby red.

‡ Oxides, sulphides, and sulphates are best reduced by a mixture of soda and borax.

§ A slight yellow color can only be attributed to iron when there is no decided color produced by either flame in highly charged beads of borax and S. Ph.

Tungsten or Titanium.—The S. Ph. bead in R. F. will be reddish brown instead of blue or violet.

Uranium.—As with chromium.

Alloys, Sulphides, Arsenides, etc.—Roast, treat with borax on coal in R. F., then treat borax in R. F. to remove reducible metals.

LEAD, Pb.

*On Coal.**—In either flame is reduced to malleable metal, and yields near the assay a dark lemon yellow coat, sulphur yellow cold, and bluish white at border.

With Bismuth Flux:—

On Plaster.—Chrome yellow coat, blackened by $(NH_4)_2S$.

On Coal.—Volatile yellow coat, darker hot.

Flame.—Azure blue.

With Borax or S. Ph.—O. F., yellow hot, colorless cold, flames opaque yellow.

R. F. Borax bead becomes clear, S. Ph. bead cloudy.

Interfering Elements.

Antimony.—Treat on coal with boracic acid, and treat the resulting slag on plaster with bismuth flux.

Arsenic Sulphide.—Remove by gentle O. F.

Cadmium.—Remove by R. F.

Bismuth.—Usually the bismuth flux tests on plaster are sufficient. In addition the lead coat should color the R. F. blue.

LITHIUM, Li.

Flame.—Crimson, best obtained by gentle heating near the wick.

Interfering Elements.

Sodium.—(*a*) Use a gentle flame and heat near the wick. (*b*) Fuse on platinum wire with baric chloride in O. F. The flame will be first strong yellow, then green, and lastly crimson.

Calcium or Strontium—As these elements do not color the flame in the presence of baric chloride, the above test will answer.

Silicon.—Make into a paste with boracic acid flux and water, and fuse in the blue flame. Just after the flux fuses the red flame will appear.

MAGNESIUM, Mg.

On Coal with Soda.—Insoluble, and not absorbed by the coal.

With Borax or S. Ph.—Clear and colorless, can be flamed opaque white.

With Cobalt Solution.†—Strongly heated becomes a pale flesh color.

MANGANESE, Mn.

‡ *With Borax or S. Ph.* O. F., amethystine hot reddens on cooling. With much is black and opaque. If a hot bead is touched to a crystal of sodic nitrate, an amethystine or rose colored froth is formed.

R. F., colorless or with black spots.

With Soda.—O. F., bluish green and opaque when cold. Sodic nitrate assists the reaction.

Interfering Elements.

Chromium.—The soda bead in O. F. will be bright yellowish green instead of bluish green.

Silicon.—Dissolve in borax, then make soda fusion.

MERCURY, Hg.

With Bismuth Flux—

On Plaster.—Volatile yellow and scarlet coat. If too strongly heated, the coat is black and yellow.

On Coal.—Faint yellow coat at a distance.

§ *In Matrass with dry Soda or with Litharge*.—Mirror like sublimate, which may be collected in globules.

MOLYBDENUM, Mo.

On Coal.—O. F., a coat yellowish hot, white cold, crystalline near assay.

R. F., the coat is turned in part deep blue, in part dark copper red.

Flame.—Yellowish green.

With Borax.—O. F., yellow hot, colorless cold.

R. F., brown to black and opaque.

With S. Ph.—O. F., yellowish green hot, colorless cold.‖

R. F., emerald green.

Dilute (¼) HCl Solutions.—If insoluble, the substance may first be fused with S. Ph. in O. F. If then dissolved in the acid and heated with metallic tin, zinc, or copper, the solutions will be successively blue, green, and brown.

If the S. Ph. bead has been treated in R. F., the solution will become brown.

NICKEL, Ni.

On Coal.—R. F., the oxide becomes magnetic.

With Borax.—O. F., violet hot, reddish brown cold.

R. F., cloudy and finally clear and colorless.

With S. Ph.—O. F., red hot, yellow cold.

R. F., red hot, yellow cold. On coal with tin becomes colorless.

Interfering Elements.

General Method.—Saturate two or three borax beads with roasted substance, and treat on coal with a strong R. F. If a visible button results, separate it from the borax and treat with S. Ph. in the O. F., replacing the S. Ph. when a color is obtained.

If no visible button results, add either a small gold button or a few grains of test lead. Continue the reduction and—

With Gold,—Treat the gold alloy on coal with S. Ph. in strong O. F.

With Lead.—Scorify button with boracic acid to small size, complete the removal of lead by O. F., on coal, and treat residual button with S. Ph. in O. F.

Arsenic.—Roast thoroughly, treat with borax in R. F., as long as it shows color, treat residual button with S. Ph. in O. F.

Alloys.—Roast and melt with frequently changed borax in R. F., adding a little lead if infusible. When the borax is no longer colored, treat residual button with S. Ph. in O. F.

* The phosphate yields no coat without the aid of a flux.

† With silicates this reaction is of use only in the absence of coloring oxides. The phosphate, arsenate, and borate become violet red.

‡ The colors are more intense with borax than with S. Ph.

§ Gold leaf is whitened by the slightest trace of vapor of mercury.

‖ Crushed between damp unglazed paper becomes red, brown, purple, or blue, according to amount present.

NITRIC ACID, HNO_3.

In Matrass with $KHSO_4$ or in Closed Tube with Litharge.—Brown fumes with characteristic odor. The fumes will turn ferrous sulphate paper brown.

PHOSPHORUS, P.

Flame.—Greenish blue, momentary. Improved by conc., H_2SO_4.

In Closed Tube with Dry Soda and Magnesium.—The soda and substance are mixed in equal parts and dried, and made to cover the magnesium. Upon strongly heating, there will be a vivid incandescence, and the resulting mass, crushed and moistened, will yield the odor of phosphureted hydrogen.

POTASSIUM, K.

Flame.—Violet, except borates and phosphates.

Interfering Elements.

Sodium.—(*a*) The flame, through blue glass, will be violet or blue. (*b*) A bead of borax and a little boracic acid, made brown by nickel, will become blue on addition of a potassium compound.

Lithium.—The flame, through green glass, will be bluish green.

SELENIUM, Se.

On Coal, R. F.—Disagreeable horse-radish odor, brown fumes, and a volatile steel gray coat, with a red border.

In Open Tube.—Steel gray sublimate, with red border, sometimes white crystals.

In Closed Tube.—Dark red sublimate and horse-radish odor.

Flame.—Azure blue.

On Coal with Soda.—Thoroughly fuse in R. F., place on bright silver, moisten, crush, and let stand. The silver will be blackened.

SILICON, Si.

On Coal with Soda.—With its own volume of soda dissolves with effervescence to a clear bead. With more soda the bead is opaque.

With Borax.—Clear and colorless.

With S. Ph.—Insoluble. The test made upon a small fragment will usually show a translucent mass of undissolved matter of the shape of the original fragment.

When not decomposed by S. Ph., dissolve in borax nearly to saturation, add S. Ph., and reheat for a moment. The bead will become milky or opaque white.

SILVER, Ag.

On Coal.—Reduction to malleable white metal.

With Borax or S. Ph.—O. F., opalescent.

Cupellation.—Fuse on coal with 1 vol. of borax glass and 1 to 2 vols. of test lead in R. F., for about two minutes. Remove button and scorify it in R. F., with fresh borax, then place button on cupel and blow O. F. *across* it, using as strong blast and as little flame as are consistent with keeping button melted.

If the litharge is dark, or if the button freezes before brightening, or if it brightens but is not spherical, rescorify it on coal with borax, add more test lead, and again cupel until there remains only a white spherical button of silver.

SODIUM, Na.

Flame.—Strong reddish yellow.

STRONTIUM, Sr.

On Coal with Soda.—Insoluble, absorbed by the coal.

Flame.—Intense crimson, improved by moistening with HCl.

With Borax or S. Ph.—Clear and colorless; can be flamed opaque.

Interfering Elements.

Barium.—The red flame may show upon first introduction of the sample into the flame, but it is afterward turned brownish yellow.

Lithium.—Fuse with baric chloride, by which the lithium flame is unchanged.

SULPHUR, S.

On Coal with Soda and a Little Borax.—Thoroughly fuse in the R. F., and either—

(*a*) Place on bright silver, moisten, crush and let stand. The silver will become brown to black. Or (*b*) heat with dilute HCl (sometimes with powdered zinc); the odor of H_2S will be observed.

In Open Tube.—Suffocating fumes. Some sulphates are unaffected.

In Closed Tube.—May have sublimate red when hot, yellow cold, or sublimate of undecomposed sulphide, or the substance may be unaffected.

With Soda and Silica (equal parts).—A yellow or red bead.

To Determine whether Sulphide or Sulphate.—Fuse with soda on platinum foil. The sulphide only will stain silver.

TELLURIUM, Te.

On Coal.—Volatile white coat with red or yellow border. If the fumes are caught on porcelain, the resulting gray or brown film may be turned crimson when moistened with conc. H_2SO_4 and gently heated.

On Coal with Soda.—Thoroughly fuse in R. F. Place on bright silver, moisten, crush and let stand. The silver will be blackened.

Flame.—Green.

In Open Tube.—Gray sublimate fusible to clear drops.

With H_2SO_4 (conc.)—Boiled a moment, there results a purple violet solution, which loses its color on further heating or on dilution.

TIN, Sn.

On Coal.—O. F., the oxide becomes yellow and luminous.

R. F., a slight coat, assisted by addition of sulphur or soda.

With Cobalt Solution.—Moisten the coal in front of the assay with the solution, and blow a *strong* R. F. upon the assay. The coat will be bluish green when cold.

With CuO in Borax Bead.—A faint blue bead is made reddish brown or ruby red by heating a moment in R. F. with a tin compound.

Interfering Elements.

Lead or Bismuth (Alloys).—It is fair proof of tin if such an alloy oxidizes rapidly with sprouting and cannot be kept fused.

Zinc.—On coal with soda, borax and charcoal in R. F. the tin will be reduced, the zinc volatilized; the tin may then be washed from the fused mass.

TITANIUM, Ti.

With Borax.—O. F., colorless to yellow hot, colorless cold, opalescent or opaque white by flaming.

R. F., yellow to brown, enamel blue by flaming.

With S. Ph.—O. F., as with borax.

R. F., yellow hot, violet cold.

HCl Solutions.—If insoluble, the substance may first be fused with S. Ph. or with soda and reduced. If then dissolved in dilute acid and heated with metallic tin, the solution will become violet after standing. Usually there will also be a turbid violet precipitate, which becomes white.

Interfering Elements.

Iron.—The S. Ph. bead in R. F. is yellow hot, brownish red cold.

TUNGSTEN, W.

With Borax.—O. F., colorless to yellow hot, colorless cold, can be flamed opaque white.

R. F., colorless to yellow hot, yellowish brown cold.

With S. Ph.—O. F., clear and colorless.

R. F., greenish hot, blue cold. On long blowing or with tin on coal, becomes dark green.

With Dilute HCl.—If insoluble, the substance may first be fused with S. Ph. The solution heated with tin becomes dark blue; with zinc it becomes purple and then reddish brown.

Interfering Elements.

Iron.—The S. Ph. in R. F. is yellow hot, blood red cold.

URANIUM, U.

With Borax.—O. F. yellow hot, colorless cold, can be flamed enamel yellow.

R. F., bottle green, can be flamed black, but not enamelled.

With S. Ph.—O. F., yellow hot, yellowish green cold.

R. F., emerald green.

Interfering Elements.

Iron.—With S. Ph. in R. F. is green hot, red cold.

VANADIUM, V.

With Borax.—O. F., colorless or yellow hot, greenish yellow cold.

R. F., brownish hot, emerald green cold.

With S. Ph.—O. F., dark yellow hot, light yellow cold.

R. F., brown hot, emerald green cold.

H_2SO_4 Solutions.—Reduced by Zn become successively yellow, green, bluish green, blue, greenish blue, bluish violet and lavender.

ZINC, Zn.

On Coal.—O. F., the oxide becomes yellow and luminous.

R. F., yellow coat, white when cold, assisted by soda and a little borax.

With Cobalt Solution.—Moisten the coal in front of the assay with the solution, and blow a strong R. F. upon the assay. The coat will be bright yellow green when cold.

Interfering Elements.

Antimony.—Remove by strong O. F. or by heating with sulphur in closed tube.

Cadmium Lead or Bismuth.—The combined coats will not prevent the cobalt solution test.

Tin.—The coats heated in an open tube with charcoal dust by the O. F. may yield white sublimate of zinc.

GALVANIZED IRON PIPES FOR ARTESIAN WELLS AND FOR THE CONVEYANCE OF DRINKING WATER.

By R. HAINES.

THE author analyzed a sample of water from an artesian well, recently sunk, 78 ft. deep, of which both the outer and inner casing were made of galvanized iron. There was no source of sewage contamination near the well, yet its composition showed per 100,000 parts 0·473 part free ammonia, and 0·008 albuminoid ammonia, only faint traces of nitrates being present, but there was a large amount of zinc in solution. The solids consisted of:

	Grains per Gall.
SiO_2, Al_2O_3, and Fe_2O_3	0·85
NaCl	0·77
$CaCO_3$	1·30
$(NH_4)_2CO_3$	1·25
$ZnCO_3$	6·52
Total solids	10·69

The analysis shows that the free ammonia has evidently been increased by reduction of nitrates of iron and zinc, and that the water undoubtedly had been previously contaminated by animal sewage.

On heating the sample the zinc separated out as a film on the surface. The author considers that the oxide and carbonate of zinc have combined with the ammonium carbonate to form the double zinc and ammonium carbonate which is insoluble in water but very soluble in ammonium carbonate, the excess of ammonium carbonate in the water holding it in solution. This combination of salts is decomposed on heating.

Experiments showed that commercial zinc and chemically pure zinc were rapidly acted on by a cold dilute solution of ammonium carbonate, which after twenty-four hours' contact gave a copious precipitate with sulphureted hydrogen on acidifying with acetic acid.

Zinc not being so accumulative as lead is less injuri-

ous to health, and, as is also known, zinc is contained in small quantities in some drinking waters in use.

The author concludes that while under the usual conditions of water supply galvanized iron piping may be used, yet too much confidence should not be placed in it. All the conditions under which this piping is to be used should be carefully considered, including a chemical analysis of the water; and, in the presence in the water of considerable amounts of certain saline substances, such as ammonia salts, chloride of sodium and nitrates, as well as very small amounts of free mineral acids, etc., galvanized iron should not be used at all. Under such circumstances, only pipes coated with a non-metallic interior surface should be used.—*Jour. Fr. Institute.*

NEW METHOD FOR THE DISCOVERY OF FAINT SPECTRAL BANDS.

APPLICATION TO THE SPECTRUM OF THE HYDROCARBONS.

By H. DESLANDRES.

THE band spectrum attributed to the hydrocarbons or to carbon alone is furnished by the sources of light most commonly used; it is also found in the solar spectrum, and constitutes to a great extent the spectrum of comets and of a certain class of stars. Its importance is, therefore, very great.

The author has studied this spectrum by a novel method which enables him to complete it and to add to it with certainty three new bands, *i. e.*, λ 438·19, λ 437·13, λ 436·5. These bands are not given by the combustion of the hydrocarbons, but they accompany the ordinary bands of the hydrocarbons and of cyanogen in the electric arc, and in the combustion of cyanogen. They were consequently at first, *e. g.*, by Liveing and Dewar, ascribed to this latter gas.

Now, the application of the general law of the distribution of bands which the author proposed (*Comptes Rendus*, 1887) for the spectra of bands, enables us to conclude that the bands in question belong certainly to the group of the hydrocarbons. This application is summarized in the following table, which shows these three bands and the sixteen known bands of the hydrocarbons arranged in five series, in which the intervals of the bands, according to the law, increase in arithmetical proportion; the series being, moreover, superposable. The bands, expressed in the numbers of vibrations, are arranged in the five perpendicular series, so that the equal intervals of the series are on the same horizontal line. At the points of a series where a band is wanting, the interval is equal to the sum of the corresponding intervals of the other series.

SPECTRA OF THE HYDROCARBONS IN NUMBERS OF VIBRATIONS.

Series I.		Series II.		Series III.		Series IV.		Series V.	
N.	Interval.	N.	In.	N.	In.	N.	In.	N.	In.
								167·94	14·97
								182·91	
						166·61			
						181·78	15·17		
				165·09					
		163·39		180·18	15·39				30·54
161·59		179·03	15·64	196·15	15·67			213·45	
177·48	15·89	194·95	15·92	212·08	15·93	212·87	31.09	229·09	16·64
193·60	16·12	211·09	16·14	228·21	16·13	228·76	15·89		

According to this table, we may, with the sixteen known bands, on setting out with seven of these bands, find by calculation exactly the nine others. On carrying out the calculation under the same conditions we obtain the three bands in question, which in numbers are represented by N 228·21, N 228·76, N 229·09. These three bands belong to the groups of the hydrocarbons.

We may even, by carrying out the calculation further, obtain the position of bands still more refrangible, *e. g.*, $\lambda = 408·35$ and $\lambda = 408·17$. But, according to all analogies, these bands must be very faint and lost in the very strong bands of the cyanogen group.

However this may be, by adding the three new bands the group of the hydrocarbons, considered as a whole, takes a form more systematic and regular, and approximates more closely to the band spectra of nitrogen, the only ones which have as yet been studied in a complete manner. These various spectra, as their study is carried sufficiently far, approach a common, uniform type, the constancy of which is due to the similar variations of the whole numbers which govern them.

This application of the law of the distribution of bands forms a new method for the discovery of faint bands which are lost in a mixture of groups of different bands. It is the first instance of the discovery by calculation of new bands in band spectra.—*Comptes Rendus.*

THE GUEREZAS IN THE BERLIN ZOOLOGICAL GARDEN.

ONE beautiful evening in August of last year a cab carrying such passengers as Europe had never seen before stopped at our office. There were three young guerezas which a Greek had brought directly here from Massaua, on the eastern coast of Africa, now so much talked of, and offered for a rather high price. After some consideration and bartering we came to an agreement, for I did not like to lose the first opportunity of presenting to our professors, artists, and lovers of animals living specimens of this race of monkeys, which has, heretofore, been known only by reputation. The opportunity was eagerly embraced, and a pleasant result of the transaction is the accompanying engraving, which is a reproduction of the first picture of these monkeys made from life, and executed by Mr. Mutzel with his accustomed fidelity to nature.

The guereza (*Colobus guereza* Ruepp.) seems to me not only one of the rarest and most remarkable, but also the most beautiful and attractive of monkeys. The excellent engraving saves me the trouble of describing his black and white coat, and I will only call attention to the tasteful contrasts, the white forming a binding and trimming for the black ground. A whole herd of these animals jumping from tree to tree as if carried along by their long fringes of hair must be a beautiful sight. If I can judge by our specimens, these side fringes and the tuft on the end of the tail do not stand out as strikingly and sharply from the otherwise smooth and glossy coat as they appeared to in all former pictures, which were not taken from life, for all the hair is very long and abundant. This is a peculiarity of the entire group of African monkeys to which the guereza belongs.

THE FIRST LIVING GUEREZAS IN THE BERLIN ZOOLOGICAL GARDEN.—DRAWN FROM LIFE BY G. MUTZEL.

This rather rare species and its representatives in Asia (the little Indian monkeys of the Semnopitheens genus) are distinguished as having very slender forms and only rudimentary thumbs or, as in the case of the guereza, no traces of thumbs on the fore hands. In the shape of its skull the guereza resembles the apes proper, especially the gibbon; its muzzle is only slightly elongated, which gives it an attractive and rather refined appearance, compared with the common monkeys. The most remarkable peculiarity in the construction of their bodies is the form of the stomach, which is bent, and hence, in a measure, divided, and is provided here and there with bands of muscle, reminding one of the stomachs of ruminants, and even more of that of the kangaroo. This peculiar formation of the stomach bears, doubtless, a close relation to the food of apes of this class, which, I venture to say from observation, consists to a greater extent of green plants, leaves, grass, blossoms, etc., than that with other apes. This opinion is confirmed by our guerezas and two other monkeys of this genus of which I have care. The guerezas receive, each day, several heads of lettuce, and they call for this particular food with a peculiar whining cry. In the hay, which I first gave them as an experiment, they find many leaves and blades of grass which they eat with the best results for their digestion.

The guereza was discovered by Ruppel, the African traveler, in Abyssinia, where it is found in all woods which grow at a certain elevation above the sea; but according to the reports of Heuglin, they are widespread in the central part of Africa. Menges, the much-traveled animal importer, to whose unselfish intercession we owe this purchase, says that they inhabit the dense woods and the deep, damp, and warm ravines of the land of the Gallas, where they enjoy life among the great fig trees and the junipers, which grow there to a height of from 59 to 72 ft.

The Abyssinians used to ornament their little, egg-shaped leather shields with the fringed skins of the guerezas, but as these shields are used less and less, the animal is persecuted very little, for it does no damage to plantations, rather avoiding human habitations. It is sometimes seen in the neighborhood of the Coptic churches, probably because these usually stand in the shade of some of their favorite trees. But here the pious Abyssinians do them no harm, and so we may hope that the guerezas will continue to abound in their native haunts. And the better we understand the care of them, the more successful will be the attempts to bring them to Europe, where they will be the chief attraction of the monkey cages in our zoological gardens.—*Dr. L. Heck, in Illustrirte Zeitung.*

THE GRAMPUS IN THE ZOOLOGICAL GARDEN AT LEIPZIG.

THE whale and the larger cetaceans are seldom seen by even the inhabitants of the coasts of Europe which lie within the temperate zone, and, of course, they are very rare sights for those who live inland; but the people of Leipzig have lately enjoyed one of these unusual opportunities, for they have had two specimens of the grampus (*Phocæna orca* Cuv. or *Orca gladiator* Gray) on exhibition in their zoological garden. These specimens were stranded near Hadsund on the Skager Rack—apparently they had been driven south by terrible storms—and were found in shallow water, where they were caught and killed. It was very difficult to get the colossi to a proper place on land and mount them so that they could be transported, but this was finally accomplished.

This animal is one of the largest of its species; the male of the pair to which we refer is 20 ft. long, while the female is 17 ft. long. The grampus is distinguished from other members of its order by its powerfully developed pectoral fins. Those of the male in question are over 4 ft. long and 2 ft. 8 in. broad in the widest part.

The different individuals of the species vary greatly in coloring, but it can be said, in a general way, that the back is black and the under part porcelain white, although the position of the dividing line is very uncertain. There are individuals in which the white is limited to a broad stripe along the belly and under part of the tail, and others which are nearly all white. Schlegel, the late director of the museum at Leyden, who had an opportunity of examining one of these animals about an hour after death, describes its skin as beautifully smooth and glossy. All the colors of the rainbow played in the black, and the white was like porcelain, although it had a yellowish tint instead of the bluish tint peculiar to porcelain. Besides the under side, the outer edge of the upper jaw was white, and there was a long white spot behind the eyes and a round spot under the shoulders. Behind the dorsal fin there was a small saddle of a dirty purplish blue which sloped off toward the front in long narrow points. A few days after death the colors lost their beauty, the white became a dirty brown, and the black lost its luster.

The animal is usually found in the polar seas and the northern part of the Atlantic Ocean, being seldom driven south of the 60th degree of latitude. It is also found in the Pacific Ocean, but here it goes farther south, and is a common sight in Japan. The Delphinidæ must formerly have been found farther south in the Atlantic Ocean also, and even in the Mediterranean Sea, for the descriptions given by Pliny and Aelianus of the *Aries marinus* (sea ram) cannot relate to any other animal, as has been shown by Cuvier.

The grampuses, like most other sea animals, move about in larger or smaller herds and are bold and daring. They eat fish, but prefer to hunt seals. They even make successful attacks on the largest whales, tearing strips of flesh from their living bodies and taking no rest until they have worried their victim to death. We can imagine that they are anything but loved by the fishermen of the northern countries and the whalers, for they boldly carry off their share of the booty, after the men have killed the animals, and as they sometimes appear in herds of twenty and are very voracious and at the same time very quick, they are an extremely unwelcome sight.—Abst. from *Illustrirte Zeitung*.

ON PEROXIDE OF HYDROGEN, OR OZONE WATER, AS A REMEDY.

CONTINUED FROM A RESEARCH COMMENCED IN THE YEAR 1858.*

By B. W. RICHARDSON, M D., F.R.S.

INTRODUCTORY AND HISTORICAL.

IN the year 1858 I commenced a study on peroxide of hydrogen with the view of introducing it into medicine as an addition to our treasury of remedies. The history of this singular chemical body, discovered in the year 1818 by the illustrious French chemist Baron Thenard, had in 1858 almost become forgotten, and no one, as far as I could learn, had ever taken it up in respect to medical research; although, as I afterward ascertained, a seat of learning at Haarlem did for some years offer a prize for a medical research upon it, which prize was withdrawn not very long before my work was entered upon, simply because there had never been a competitor. The peroxide when I commenced my investigations was so rare a chemical curiosity that I could not obtain it in quantity, and was therefore obliged to set up the necessary apparatus for its manufacture in my own laboratory. In the manufacture I followed in every particular the instructions left by Thenard, and continued the manufacture until I could assign good reasons for advancing the fluid into the position of a valuable remedy in the treatment of disease. The great novelty of the peroxide solution—for the substance must be considered a solution, although it can be made to take the gaseous form—rendered the study of its physical properties alone of extreme interest, and, as it still remains a novelty to many, I may with advantage devote a few moments to description of one or two of the special qualities of the solution; otherwise I might be talking an unknown language to some who are not conversant with certain primary facts, themselves unique in the history of chemical substances. This solution, then, is water containing, according to strength, so many atmospheres of oxygen. It is an oxygen atmosphere in solution. It is not, however, a mere mixture, but a peculiar chemical compound. The oxygen can be made to accumulate, volume by volume, until the volume of water, say as much as would fill a pint measure, can rise to ten, twenty, thirty, and some say even over a hundred volumes of oxygen, before complete saturation is reached and a volatile body is formed. In the specimens on the table before us, prepared by Mr. Robbins, we have solutions of three strengths, viz., of ten, twenty, and thirty volumes. We hold, therefore, in a specimen of the peroxide condensed oxygen chemically combined either with the hydrogen of the water, or with the oxygen of the water, or with the two elements acting as a radical. There is here not much difference at first sight from what is common in combinations where there is accumulation of one element on another; as, for example, in the case of carbon with one equivalent of oxygen as in carbonic oxide, and carbon with two equivalents of oxygen as in carbonic dioxide. But now comes a distinction. The combination of the added oxygen in hydrogen peroxide is stable in the presence of some substances, unstable and easily evolved in the presence of others. Some substances, inorganic or organic, when added to the solution, are neutral; other substances, inorganic or organic, evolve the oxygen and are themselves unchanged; a third kind evolve the oxygen, and with that some of their own contained oxygen; a fourth kind absorb the oxygen into themselves.

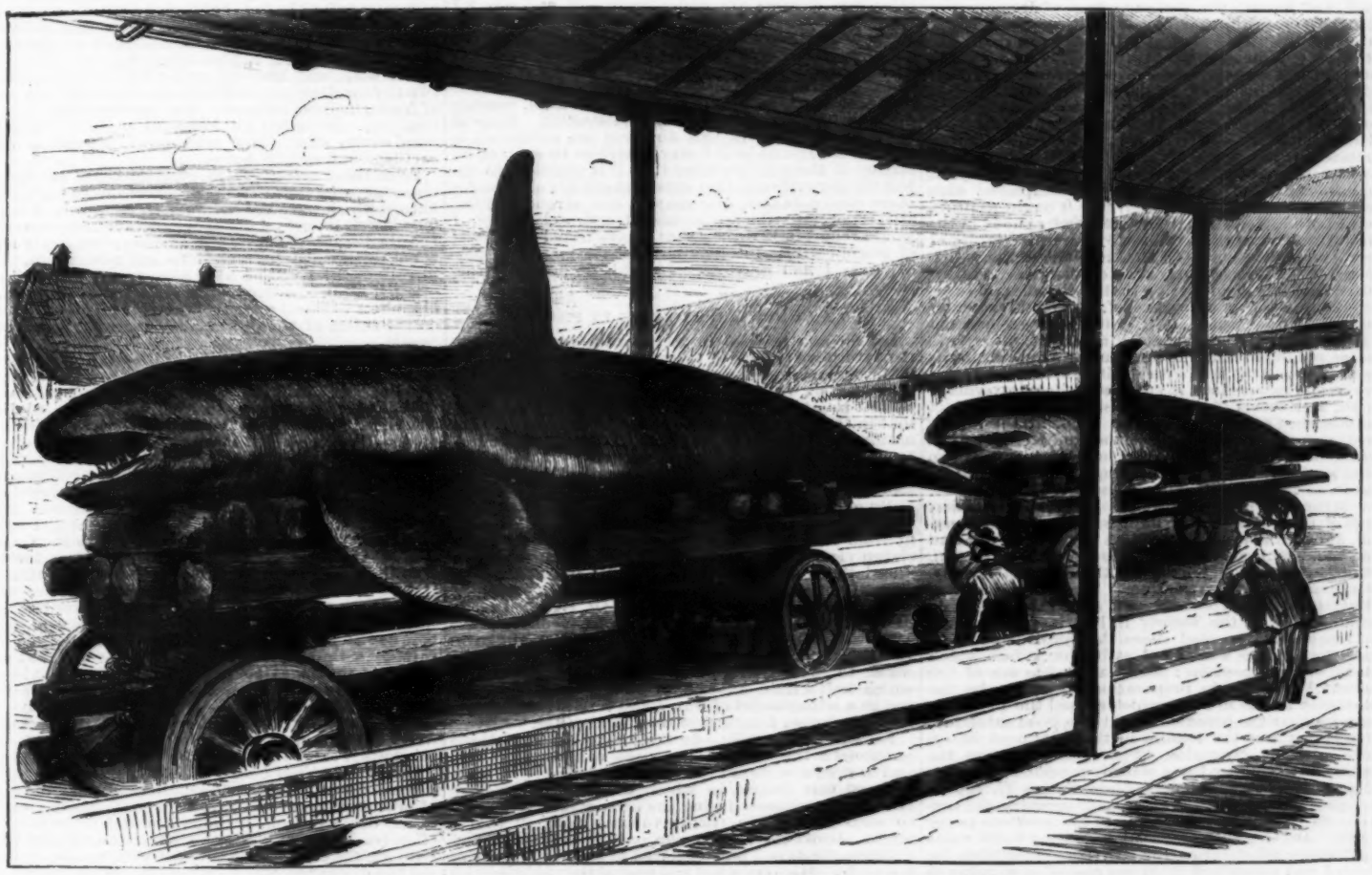
I will illustrate this by experiment. Here are flasks equally charged with a ten-volume solution of the peroxide. To flask *one* I add a portion of oxide of iron; the action is neutral. To flask *two* I add black oxide of platinum; there is brisk action, so that I can light a taper from the oxygen thrown off. To flask *three* I add solution of permanganate; there is very brisk action, and, with the action, evolution of oxygen from the permanganate as well as from the solution. To flask *four* I add arsenious acid; there is absorption of the oxygen by the arsenious compound. These are inorganic bodies; let me compare them with organic. Into flask *five* I put albumen; the action is neutral. Into flask *six* I put fibrin; there is brisk evolution. Thenard, in a general way, had a wonderful knowledge of these distinctions, but he did not live to follow them out or apply them. They are all important to our medicinal labors, in pointing the way to success by the experimental instead of by the empirical mode of questioning nature.

These observations led me very early in my research to form an original view as to the constitution of the fluid. When I liberated the oxygen from the solution, by one or other of the means described above, I found that the oxygen was neutral—that is to say, it presented neither ozonic nor antozonic qualities, but was like the oxygen of the common atmosphere in its natural state. When, however, it existed in solution in the form of peroxide, it responded to ozone tests, rendering the ozone test papers of deep, dark color, as I now demonstrate. These facts led me to conceive that the extra oxygen exists as ozonized oxygen, ozone, in combination with water, so long as it is in solution; but that, as it comes off from the solution, it escapes as atmospheric oxygen. This theory has met with opposition, for which I have much respect, but I still hold by it; and I call special attention to it here because, from a medical point of view, it is of primary importance. As I shall show, we use the oxygen of the solution in two forms: sometimes as a solution, when it is ozonic; and sometimes as a gas liberated from the solution, when it is neutral. The difference is great; it is the difference between ozone and oxygen, and until the profession understands that difference, the utmost confusion must prevail in regard to therapeutical action.

It may gratify a new generation of fellows of the Medical Society of London if I briefly relate what led me to use this solution in the first instance. It was in this way: I was working at ozone, and had been studying, with the late Dr. Moffat, of Hawarden, the changes of disease in what he called "atmospheric ozone periods." I made peroxide, and found that the oxygen condensed in it colored Moffat's ozone test papers of starch and potassium iodide, a fact which showed that this oxygen was more active than the oxygen of common air. It then occurred to me that the peroxide might be of service as a medicine if its action on the animal body and on the tissues were well investigated and defined. In those days we were inclined to believe that diabetes was due to the deficient oxidation of organic material—a theory which an original observation of mine, namely, that dogs could be made to eliminate urine containing glucose by subjecting them to an atmosphere of carbonic oxide, seemed to confirm.

As a result of this line of thought I made an original investigation, the results of which I reported at length in a paper read to the Medical Society in the session of 1860, describing the chemical, physiological, and thera-

* Essay read before the Medical Society of London, on Monday, March 23, 1891.



THE TWO GRAMPUSES IN THE ZOOLOGICAL GARDEN AT LEIPZIG.—FROM A PHOTOGRAPH.

peutic action of the peroxide. I also fixed in this paper the best form of the peroxide of oxygen for medical use, suggesting ten volume strength as the most certain and convenient for ordinary use. At the meeting of the Society on March 3, 1863, under the presidency of the late Mr. William Coulson, I made a second report on the medicinal use of the peroxide. I had by this time used it in 223 cases of disease, including cases of phthisis, diabetes, anæmia, subacute and chronic rheumatism, strumous enlagement of the cervical glands, mesenteric disease, pertussis, chronic bronchitis, chronic laryngitis, mitral disease, and some forms of dyspepsia. On referring back to these two communications to the Society, I find in them a good deal of new physiological inquiry. I find that I had tested all the free tissues of the body to learn which of them did and which of them did not eliminate the oxygen by contact. I found that fibrin of blood and cellular tissue liberated the oxygen, that albumen and gelatine did not liberate it, that blood entirely deprived of fibrin absorbed the oxygen; and that common water deprived of all its gases so efficiently that fish could not live in it could be reoxygenated and revitalized by addition of the peroxide solution, but not to the same perfection as obtains in water that has not been deprived of its natural air. It was also in these researches that I observed for the first time the remarkable influence of temperature on the action of the oxygen on the body; that heat caused oxygen to lose its power of sustaining muscular contractility, and that by it oxygen could be made a relaxant even of tetanic spasmodic rigidity. What, however, will interest most a practical body of men like the members of the Medical Society of London will be the *résumé* of the therapeutical properties of the peroxide from those earliest papers. The *résumé* was as follows: In the paper of 1860 it was advanced (*a*) that the peroxide quickens oxidation, increases secretion, arterializes blood, and hastens the decomposition of decomposing animal tissues; (*b*) that in combination with blood it restores the power of muscles just dead to contract, and yet calms muscular irritability; (*c*) that it promises valuable aid in a large number of cases of disease; (*d*) that in instances of poisoning by narcotics and by the alkaloids it might with advantage be introduced into the blood by transfusion or injection; (*e*) that in tetanus it affords a most rational treatment, since tetanic rigidity is relaxed by its presence in muscle; (*f*) that in typhus, in which death occurs from what I designated *asphyxia commencing in the blood*, it might be employed with good effect as an oxygenator; (*g*) that it ought to prove useful both as an internal and external remedy in the treatment of cancer. In epitome of results in 1863 I drew the conclusions: (*a*) That in diabetes the peroxide reduces the specific gravity of the urine, while it rather increases quantity; (*b*) that in chronic and subacute rheumatism it affords relief; (*c*) that in valvular disease of the heart with pulmonary congestion it gives relief to the dyspnœa; (*d*) that in mesenteric disease and in jaundice it causes an improvement in the digestion; (*e*) that in pertussis its effect for good is very remarkable, since it cuts short the paroxsyms of cough, and seems decidedly to shorten the period of the disease; (*f*) that in chronic bronchitis it lessens the dyspnœa, and renders the expectorated matter less tenacious; (*g*) that in chronic laryngitis it gives pain on being swallowed, and does not appear to be useful; (*h*) that in anæmia it does not of itself render a service, but favors the good effect of iron; (*i*) that in the first stage of phthisis it causes improvement in the digestion, and in the later stages gives unquestionable and even wonderful relief to breathlessness and oppression, acting, in fact, like an opiate without producing narcotism, and assisting oxidation.

But the most important new observation I had to communicate to the society in 1863 was that in free and frequently repeated doses the peroxide could be made to produce a modified salivation, a fact which led to two suggestions: one, that in the use of the mercurial and iodide preparations it might be the chlorine or iodine in them which caused the ptyalism; secondly, that the peroxide would be a good substitute for mercury and the iodides in the treatment of syphilis. In the discussion which followed upon the reading of this paper I was warmly supported on several points by Drs. Septimus Gibbon, Symes Thompson and Gibb, all of whom had been prescribing the peroxide on the suggestions made in the previous paper of 1860. Dr. Gibb bore special testimony to its value in affording relief during the last stage of phthisis, for which I had prescribed it in the case of a member of his own family.

Such in the briefest terms is the history of the introduction of the peroxide of hydrogen, as it is commonly called, or ozone water, as I should call it, into medicine. Soon after it was thus introduced it created a great deal of discussion, but owing to difficulties in its manufacture and some instability of the earlier specimens of it, it fell out of favor, except in two unexpected directions. An incidental observation of mine that the solution gave a golden color to feathers led to the employment of it as a golden hair dye; while a similar reference to its effective action as a deodorant and disinfectant led, I believe, to its use in that very excellent compound called "sanitas." Occasionally also it was employed in medicine, and now and then I was consulted in regard to its employment. Matters remained in this state until about five years ago, when by some sudden and inexplicable impulse the peroxide began to become popular in medical practice, especially in America, and from that time onward I have had communication with practitioners, both at home and abroad, who were anxious to be informed on points of a practical kind relating to it. It was this circumstance that led me three years ago to propose to revive the subject in the Medical Society of London, and finally to bring forward the present paper. This was the more necessary because, although practitioners who are now largely prescribing the remedy have often in the most handsome manner assigned to me the credit of originating the practice, they do not seem to have seized on the principles which led me to introduce it, nor to see the compound nature of the fluid and the different lines of practice which spring from that recognition. Meantime, in the twenty-nine years that have elapsed I have continued to work at this research; practically in the steadiest manner, theoretically by fits and starts, as the opportunities of my overcrowded life have permitted. Now, as a kind of continued report, I propose to give a further account of my stewardship during the gap of time that has supervened since I last spoke on this topic from this place.

NEW METHODS OF APPLICATION.

In carrying out this idea let me notice in the first place a few new facts bearing on modes of administration which did not in any way belong to the previous communications to the society. Some time about 1863 I made an observation regarding the behavior of the peroxide with ether. In agitating a thirty-volume solution of the peroxide with anhydrous ether, I found that the ether became ozonized, and that it was in this way possible to make a new and useful medicinal preparation. To the preparation so formed I gave the name of ozonic ether, and from the time when it was first announced to the present it has been utilized. The late Dr. Day, of Geelong, in Australia, sent to me early for the mode of preparation, and having learned to use it in his own practice, devoted to it much study up to the end of his valuable life. He warmly supported my application of the fluid in the treatment of whooping cough and its use as an inunction after scarlet fever. He it was who first employed this compound with guaiacum as a blood test. The admixture of the peroxide with a volatile compound like ether led me to another modification—namely, the administration by inhalation of the oxygen evolved either as oxygen, ethereal oxygen, or ozone, for I soon learned that it could be administered, as I shall show presently, in all these states. This was a distinct advantage, as it enabled me to move from the mode of administration by the mouth to a larger and, in cases of lung disease, a more direct method. Taking further advantage of the ozonic properties of the peroxide in solutions, I introduced it in 1865 at the meeting of the British Medical Association at Chester for the deodorization and disinfection of rooms in which patients suffering from infectious diseases are under treatment, and also for application as spray to fetid or ulcerated surfaces, as in diphtheria, syphilitic ulceration of the throat, and gangrene. For this purpose it may be used either as ozonic ether or simply as the aqueous solution. In addition to the above new progressions I have made others of a physiological and practical kind, bearing on other possible methods of administration. Some of the facts disclosed in this direction are published in the last *Asclepiad*, and I may therefore be content by stating of them in summary that it is practical to inject the peroxide solution subcutaneously; also, under some circumstances, into mucous and serous cavities, and even into the pulmonic structures. Lastly, I would report in this place that I have tested the effects of morbid substances like purulent matter on the peroxide, as I had previously tested it on normal structures.

OLD AND NEW EXPERIENCES IN PRACTICE.

Let me now proceed to compare the practical experiences I have gained in the use of the peroxide since 1862. In the previous reports I dealt with many cases of disease in which I had applied this remedy; and in respect to all the forms of diseases specified I may say that in the long experience which has succeeded I have nothing of moment to retract, little to modify, much to emphasize and support.

Diabetes.—I have many times prescribed the peroxide solution in this disease since 1862. In four cases, specially noticeable because occurring in members of our own profession, the patients were all satisfied of benefit from it, one of them taking it during a period of eleven years. The results have always been that it reduced the quantity of sugar, but did not reduce the quantity of water eliminated, unless it were combined with codeine, with the use of which Dr. Pavy has made us so familiar. Codeine three grains, alcohol (sp. gr. 0·830) two fluid drachms, solution of peroxide of hydrogen (10 volume strength) two fluid ounces, distilled water to make twelve ounces, makes a mixture of which half a fluid ounce may be taken three times a day in a wineglassful of water, and forms the most useful prescription I have ever used in diabetes.

Phthisis Pulmonalis.—In the treatment of phthisis pulmonalis the solution has been constantly in use, and in it I have found the greatest service. In some cases of this disease, in which the solution has been borne in large doses during the early stages, it has led to such remarkable results toward recovery that I might almost have been pardoned if in younger and enthusiastic days I had declared in it the discovery of a specific. Happily a natural fear of the *experimentia fallax* held me back from such a course; but the fact ought not to prevent me from stating that in the first stages of phthisis it is of all medicinal remedies I know the most valuable, and that in the later stages, when dyspnœa is the distressing symptom, it is, especially in combination with ozonic ether, the remedy that gives most relief. It soothes, and it seems to supply oxygen to the blood, and so act vicariously, to a small extent, for the purpose of respiration.

Pertussis.—I repeat all I previously said about the value of the peroxide in the treatment of whooping cough. I am sure there is nothing so near to a specific for this affection. The only difference I have instituted in the employment of it in this disease consists in prescribing it in the form of ozonic ether. I prescribe it for children in this form, in doses of from ten to sixty minims, diluted with half a fluid drachm of spiritus tenuoris, and four drachms of water, to be taken four times a day, with a little more water if that be preferred. But I also prescribe the ozonic ether in this disease by inhalation from the Siegel spray inhaler. In one instance, where the paroxysms were as severe as I have ever seen them, they were arrested at once by this inhalation, and were held in such control by continued inhalations that what may be called a "cure" was the immediate result. As to the power of the oxygen to control muscular spasm, I repeat with still more insistence its value. In practice I have availed myself of the peroxide with ether, not only in whooping cough, but also in asthma and in angina pectoris. Here the ethereal solution can be used by inhalation in its simple form, or combined with amyl nitrite, or other body of the antispasmodic class that will admix with ether and diffuse with it. In these affections I administer by inhalation in a manner that will be demonstrated in the last section of this essay.

Local use for ulceration and purulent exudation.—In the paper of 1863 I recommended the use of the peroxide for external application in cases of surface decomposition, ulceration, and purulent exudation. I have to emphasize this use. I will name one case alone in illustration. I was called to see a gentleman advanced in life who was suffering from moist senile gangrene of the foot. The extremity was so offensive and the separation so slow, although there was a fair line of separation, that the management was most distressing. I had the foot wrapped in cotton wool holding peroxide solution slightly acidulated with dilute hydrochloric acid. The offensive odor was at once removed, and the process of separation went on rapidly; the foot soon fell off, leaving an excellent healing surface. The patient lived many years afterward in fair health, and died at last of mere old age.

Syphilis.—I restate the value of the peroxide in syphilis, and especially in all the chronic stages and conditions of syphilis in which mercury or potassium iodide would, usually, be resorted to. It seems to me, in these cases, to have an intermediate action between mercury and potassium iodide. It is also useful in indolent syphilitic eruptions, and it has the great advantage over both mercury and the iodide that it leaves no after effects of an injurious character. Salivation from large and frequently repeated doses is soon recovered from when the fluid is withdrawn, as if the ptyalism had been induced by a volatile substance. It also aids the action of mercury, rendering much smaller doses of that remedy effective. The property exemplified in this action is that of elimination by excitement of glandular function, an excitement probably always sustained by the oxygen of the tissues in normal states of health, and only accelerated by the active oxygen. I have of late years become so confident of the value of the peroxide in the treatment of syphilis under the conditions in which mercury or iodide come ordinarily into use that I have employed it as a matter of course. I use it in the primary as well as the secondary form of the disease, and for those cachectic lesions in the syphilitic constitution to which the term "tertiary" is applied. There is, I think, no remedy equal to it. In obstinate cases of ulcer and cutaneous eruption it goes admirably with the mercurial bath, and may be prescribed in doses of from two to four drachms three times a day with full doses of fresh cinchona infusion. The solution also has its local use. It makes an excellent injection into the nasal cavity when there is syphilitic ulceration of the cartilage and spongy bones.

From these references to practice based on the old observations I pass to some observations of a practical nature which have not before been recorded. I might have dwelt longer on old experiences in respect to mesenteric disease, epilepsy, and anæmia; but as my mind is not so satisfied in regard to any advance in these directions, I let what I have already said remain in its original form, in order to give room for what is new. I also allow to stand over for future comment some notes on the action of the peroxide on digestion and in dyspepsia.

Use in Diphtheria.—Owing to the observation made on the effect of the peroxide solution in causing separation of dead from living structures, I have several times used it since 1864 as a local application of diphtheria, in the treatment of which hitherto inscrutable disease I have had the most painful of human experiences. Applied to the throat in diphtheritic patients, the solution of peroxide, either alone or in combination with glycerine, causes, without any doubt, a rapid separation of the false membrane, and produces a favorable condition of the local surface. But here, I regret to say, the benefit—and it is a benefit—ends. On the general or constitutional conditions it has not as yet, according to present modes of using it, been efficient. It does not touch the collapse. I name this because I see that some writers, observing the good local effect in cases that have for some other reason recovered, have, *post hoc et propter hoc*, proclaimed the peroxide as a specific in diphtheria. It has as yet not won that position. At the same time I invariably prescribe it locally in diphtheria, not only to the throat, but as a wash for the nostrils when there is ichorous and offensive discharge. The twenty-volume solution can be applied freely to the fauces, with borax or with glycerine, and to adults it can be administered in the form of spray.

Use in Intestinal Cases.—The administration of the peroxide solution as an injection per anum was a line of practice that occurred to me about 1870 in a case of cancer of the rectum, accompanied with a free and very offensive discharge. The action of the solution in destroying the odor, and, combined with tannin, in limiting the discharge, was most useful. Soon after that I was summoned to a patient suffering from what I may designate as strumous caries of the sacrum, with adhesion and ulceration of the lower intestine and copious escape of pus into the rectum. A more painful case, or one more difficult to manage, I do not remember to have seen. Here I prescribed the ten-volume solution, with tannin and dilute hydrochloric acid, by injection, with the best results. The disease proved fatal, for the whole of the sacrum was involved before the use of the oxygen solution was commenced, and after paralysis of the lower extremities had supervened. But the solution exerted such a controlling influence, and rendered the discharge so healthy, I could but regret that the treatment by it had not been brought into action at an earlier stage.

In a case of what was called chronic dysentery, with frequent motions of a fluid and offensive character, I prescribed the ten-volume solution, with tannin, in ounce doses, diluted with a pint of tepid water. The injection was thrown into the bowel once daily through a long O'Beirne tube, and as the oxygen was liberated freely in the intestine soon after the injection was thrown in, the evidence was supplied of the excretion of purulent fluid, or of some excreted matter from blood. The result was very satisfactory, and led to such a rapid and sound recovery that I can recommend the repetition of the practice with the utmost confidence.

Use by Inunction.—From a similar line of thought and practice I have for many years used the peroxide as an inunction for the surface of the body of patients affected with cutaneous exfoliation, as in scarlet fever and measles. In these instances the ozonic ether is used instead of the aqueous solution, because of the facility with which it mixes with the oil or lard required to make an ointment. The body is rubbed from head to foot with the ointment, the spaces between the fingers, toes, and flexures of joints being included. The application is very agreeable to the patient, and

the effect in removing obnoxious odor is most marked. But the grand advantage lies in the circumstance that the process seems to remove all danger of infection from the convalescent after three or four applications.

Use in Eczema.—As a general rule, oily and fatty dressings do not agree well in chronic eczema. But I once gained considerable advantage by treating a chronic eczema, which had previously and for a long time been most intractable, with an ointment of spermaceti saturated with ozonic ether. In other eczematous cases, with exudation of blood, I have employed the aqueous solution with tannin with great advantage. In cases of this nature, where there is great irritation, the solution goes well with an anodyne.

Use in Diagnosis.—I have found the peroxide of hydrogen of great service in diagnosis. It diagnoses pus from mucus. In cases where I am in doubt whether matter expectorated by the lung is or is not purulent I perform the following test. I place the expectorated matter in a test tube containing the solution. If the matter causes no evolution of oxygen, there is no purulent matter present. If the expectoration produces liberation of oxygen, the evidence of pus is strong; and if the same event occurs after all carbonic acid is removed, the presence of either pus or of some plastic element of blood or cellular tissue element may be affirmed of a certainty. In the first test tube which I now take up there is secretion I do not suspect, and on adding to it some of the twenty-volume solution there is, as you will see, no action whatever. In the second tube there is some doubtful secretion; but again we see there is no action. The third tube holds a few minims of secretion strongly suspected to be purulent, and on addition of the solution the vehement action confirms the suspicion. In the large majority of instances it will be pus that is present, but the diagnosis extends to cellular tissue. Injected into a closed mucous cavity, like the bladder, the surface being in a healthy state, and the viscus having been emptied of urine and washed out with warm distilled water, there is no liberation of oxygen from a neutral solution of peroxide. But if there be any ulceration, by which a surface of cellular tissue is laid bare, or if there be pus present, then the escape of oxygen will be so free from two or three ounces of a ten-volume solution injected into the bladder that the gas may be detected as it escapes from the free end of the catheter by its effect in relighting a partly extinguished taper. The same test might be applied for the diagnosis of ulcerated mucous surface, or presence of pus in the uterine cavity, and possibly also the stomach, but no opportunity has been offered me of testing in these last named cases. I may, however, add that no more mischief could follow from the test than would follow from the injection of common water or common atmospheric air, if the solution made be chemically pure; on the contrary, the ozonic quality of the oxygen in the solution would tend to have a good effect. It might be sound practice, indeed, to sustain in some forms of ulceration a gentle continuous current of the fluid through a mucous cavity. In extensive ulceration of the bladder or uterus, accompanied with offensive discharge, this treatment offers promising results.

SUGGESTED NEW PRACTICES FROM PAST EXPERIENCES.

In the course of original research it often happens that a number of side suggestions and thoughts occur to the mind which were not dreamed of when the research commenced. In this way theory is brought out which, being an induction from experiment, may easily become practice, and that, too, of a valuable character. As a rule, it is good for the investigator not to advance theory even of this order until he himself has put it to the test. But there are exceptions to every rule, and here seems to me to be one. Some suggestions leading to important lines of practice have forced themselves on my attention, which call for proofs I can hardly hope to make in my own lifetime, but which younger men may have the opportunity of making, and which I, therefore, proceed to state without reserve; and the more readily because really in some instances the way toward practice has been opened for a considerable distance with perfect safety. Let me take as a first illustration of this kind an extension of the practice of injecting the peroxide solution into mucous canals. I have indicated, as a practical fact, that the solution can be injected into the alimentary canal, and that in more than one example it deodorized and neutralized an offensive discharge in a most effective manner.

Typhoid.—I would venture further. I would recommend the practice in the treatment of typhoid fever. In typhoid fever it would be possible to throw into the canal by this means twenty pints of ozonized oxygen per day by using only one pint of the ten-volume solution. The gas when liberated would diffuse through the whole of the canal, and would decompose and oxidize the decomposing exuded products, which by secondary absorption are the cause of the relapsing febrile seizures, with an efficiency possessed by no other remedy. It would be like exposing the decomposing ulcerated surface to ozonized sea air.

Hypodermic and Subpulmonary Injection.—As in physiological research I found no danger from injecting the neutral solution of the peroxide into the cellular tissue, I would venture the same on the human subject, and I fully expect that the practice will in time be largely adopted. In asphyxia, as after drowning and after suspended animation from chloroform and other narcotics, a hundred pints of oxygen might easily be transfused, hypodermically, by using the thirty-volume solution; and, with the temperature of the solution raised to blood heat, the diffusion of the gas through the cellular tissue would oxidize the blood rapidly, and tend to give a new force to the circulation. I should even go one step further in extremest cases. In sudden collapse from chloroform, if the natural respiration had actually ceased, and death seemed to have occurred, I should, to save time, while sustaining artificial respiration, inject the lung cavity directly on both sides of the chest with the solution. The diffusion of the gas through the lung structure would arterialize the blood remaining in the lung, and the mechanical pressure exerted within the pleura against the elastic structure would be a motor to the circulation, compressing the blood toward the left side of the heart, and producing a current of blood from the right side. For these subcutaneous and subpulmonary injections of the peroxide I have invented a new automatic syringe, which can be used without withdrawing the needle, the piston movement being sufficient for filling as well as for emptying the syringe. There would be no danger of injecting four ounces of the thirty-volume solution, rendered neutral and warmed to the normal blood temperature, into each thoracic cavity by needle puncture through an intercostal space high up in the forepart of the thorax. The water might produce a little œdema, but it would soon be picked up, and carried into the circulation by the capillary vessels. Bearing also on this subject of subpulmonary injection there is another use of the solution which has often occurred to my mind, and which would be perfectly legitimate as a practice, when the powerful action of the peroxide in destroying decomposing and purulent matter is taken into account. I suggest that in cases of cavus of the lung in phthisis, where the cavity can be clearly defined, there would be no risk of injecting the cavity, through a fine needle, with the solution, and of oxidizing all the fluid that it might contain. Again, in dangerous hæmoptysis it would be most legitimate practice to inject into the pulmonary structure the oxygen solution saturated with tannin. The oxygen could do no harm, and the tannin, which would be quickly transformed into soluble glucose, would merely charge the blood with a useful saccharine food, with the advantage of making the lung, in a small degree, a kind of second stomach. Still more, it is quite worthy of serious consideration whether it would not be good practice to inject the solution in small quantities by the subpulmonary method in the early stages of phthisis. The oxygen would destroy the tuberculous exudation more quickly than any other agent, and I can see no danger of diffusing oxygen through an organ that is made for the sole purpose of receiving and condensing oxygen. The one danger would be hemorrhage, and that could be met by combining tannin with the solution. I name this new mode of treating the lung substance "the subpulmonary." In a word, my contention is that we may learn to transfuse the peroxide solution without risk and with benefit into the lung, and indeed into any organ of the body, not excluding the brain and nervous centers themselves. The only danger that could follow would arise from delivering into the tissues so much oxygen at once that the blood would not absorb it with sufficient rapidity to allow afterward a free course through the minute circulation.

I will show you an experiment on this point in order to illustrate what I mean. Here is a two-necked flask charged with six ounces of defibrinated blood from an ox. The blood has been deprived of all free carbonic acid by being washed with oxygen. It is of bright arterial color, and if a current of air free of carbonic acid be driven through it into lime water, there is no trace of carbonic acid. But when to this blood I add neutral peroxide solution, there is, even though it is already arterialized to some extent, brisk action. There is more oxidation, there is a slight elevation of temperature, and there is free escape of gaseous matter from the free tube and by the flask through the lime water. The gaseous matter escaping consists partly of liberated oxygen, but, as shown by the precipitate in the lime water, there is also carbonic acid; and had the blood been venous, the amount of carbonic acid would have been very considerable. Thus it is clear that liberation of carbonic acid in the venous circuit from the use of peroxide may occur; and as there is no escape within the circuit for the gas or gases, there is the same danger as there would be from blowing air into a vein. I observed this fact in an experiment recorded in the last number of the *Asclepiad*, in which I restarted respiration in a lower animal, after death from chloroform, by injecting peroxide solution into the peritoneal cavity. The respiration was so good that life seemed to be returning until the vital functions were arrested from some other cause telling upon the circulation. After death it was found that the right side of the heart and large veins were filled with a bright arterialized blood richly charged with oxygen gas that had been absorbed from the large veins, and with which carbonic acid gas was also admixed. The prevention of this source of danger has to be worked out. It may be done by using a weak peroxide solution, or by using an alkaline solution. Meantime the danger ought to be known and the nature of it understood, since its existence without being understood might interfere materially with the proper application of the peroxide in its most useful and innocent administrations.

Use in Tetanus and Hydrophobia.—I have spoken of the effect of the peroxide in relaxing muscular contraction, and the facts I have observed in this direction lead me to suggest its use in two particular diseases of the spasmodic type, hitherto so intractable—I mean tetanus and hydrophobia. Any one who has watched the course of one at least of these diseases (tetanus) will feel that the treatment the most of all hopeful, if it could be realized, is a means for preventing the muscular tetany, for producing free glandular elimination, and free oxidation of the septic blood. In the peroxide solution we have all these requisites, and in the next case of tetanus that comes under my care it is my intention to put the remedy to the completest trial. I shall inject the muscles in groups with the neutral ten volume solution, heated to blood temperature, adding, if the oxygen be not alone efficient in reducing the tetanus, a weak alcoholic solution of amyl nitrite.

Mechanical Use.—One other purpose for the peroxide must be named—a purpose purely mechanical, and yet not to be slighted. In the process of being liberated from its solution the gas exerts an expansion, which in many instances may prove of great service. In this mechanical mode of application it could be used in obstruction of the bowels from intestinal involution. It could be used for causing distension of the bladder when the sound was being employed, and perhaps in stricture for producing dilatation of the passage posteriorly to the stricture. In the same manner it could be brought into play for dilating the uterine cavity; while for bringing on premature labor, in instances of contracted pelvis, the effect of the equal distension by the gas liberated from three or four ounces of the ten volume solution would, I suspect, be as rapid as it would be safe and effective.

NEW PHARMACOLOGICAL RESEARCH.

Let me describe in the last part of this essay some pharmacological outlines. Peroxide of hydrogen is still made, as Thenard first made it, by the action of an aqueous acid solution on peroxide of barium, the number of volumes in each specimen turning on the number of precipitations. I originally proposed a ten-volume solution for medical purposes, and that has been well adhered to; but for special purposes a solution of twenty and even thirty volumes may be employed. In order to keep the oxygen in the solution it is necessary to have it slightly acidified, either by dilute nitric, hydrochloric, or phosphoric acid; and, for my part, I prefer the dilute phosphoric acid. In this form the solution can be administered internally in doses varying from a fluid drachm to a fluid ounce; but two or four drachms, diluted in ten fluid ounces of water, may be considered an average dose. The taste is peculiar, being identical with that of ozone when inhaled by the mouth, and not at all dissimilar to the taste of chlorine in a weak solution. For injection purposes the solution should be rendered neutral by the cautious addition to it of caustic soda or potassa. The soda I think is the best; but it should not be neutralized until the time it is wanted. In ten volumes it may be injected either into the cavities or into the cellular tissue without being further diluted. The solution of the peroxide is incompatible with many substances; but it is compatible with the following: the mineral acids, tannin, alcohol, glycerine, alcoholic solutions of the alkaloids, and alcohol combined either with ether, amyl hydrate, amyl nitrite, or iso-butyl.

ADMINISTRATION BY INHALATION.

The oxygen from the peroxide can also be administered by inhalation by means of a simple apparatus which I have constructed for general use, and in working which I have taken advantage of another oxygenated body that liberates the oxygen and at the same time yields up a portion of its own oxygen. Into a glass vessel having two necks, like the ordinary Woulf's bottle, a few ounces of the peroxide solution are placed. A tube from a funnel, the tube having a stopcock, runs through the stopper of the bottle to the bottom of the contained solution. From the second neck of the bottle there springs another tube for inhalation, at the free end of which is a double-valved mouthpiece, like the oldest and best of the chloroform inhalers. The apparatus is now ready for use. When it is wanted the funnel is charged with a solution of permanganate of potassa in the proportion of ten grains of the permanganate to a fluid ounce of water. The tap is then turned, the permanganate solution flows into the peroxide solution, and, immediately, oxygen derived from both bodies is briskly evolved. This, if necessary, can be caught in a flexible balloon, or bag, from which it can be inhaled in measured doses, but this is not a requisite. Should the practitioner desire to combine the oxygen with ether, or with any other volatile body, soluble in ether but not in water, he can allow the ether, or ethereal solution, to float on the top of the peroxide solution. Then, as the oxygen escapes, the ether, or the ether with its other volatile comrade, passes over in combination with the oxygen. A patient can help himself to a dose at any time, as may be directed, by merely adding a measured quantity of the permanganate solution. Nitrite of amyl can be inhaled in this manner with ether, and, in short, there is here a means of administering most of the active volatile medicaments by inhalation, and in a form most ready for combination with the blood, as it passes in its course over the pulmonic circuit. How easily the apparatus can be brought into use will be seen by the demonstration here made. Under the form of ozonic ether the administration can be carried out either as a medicine to be taken in water, or as spirit solution by the mouth, in doses of half a fluid drachm to two fluid drachms, or as fine spray from the Siegle steam inhaler. For a styptic and deodorant spray for the throat the following form is useful: alcohol, pure (sp. gr. 830), half a fluid ounce; tannin, pure, twenty grains. Dissolve the tannin in the alcohol with an ounce of distilled water, and then add solution of peroxide of hydrogen (ten volume strength) to six fluid ounces. To make a solution for spray. Of this solution, one or two fluid drachms can be used with Siegle's steam spray inhaler, a mode especially applicable in cases of throat affection. When the peroxide spray is brought into use for the throat, it is good practice, in some instances, to make the spray the means of administration, in small doses, of medicinal agents which may act internally. Quinine may be administered in this manner, and also soluble preparations of opium, and many other substances that are soluble in alcohol, and are, at the same time, compatible with the oxygen solution.

SPRAY FOR THE SICK ROOM.

Reference was made in the first part of this paper to ozonic or sea spray for the sick room—a solution diffused in the air as spray from a spray producer. The solution is composed of the solution of peroxide of hydrogen (ten volume strength), ten ounces; common salt, two drachms. If a pleasant and pine tree odor be desired, a few drops of ethereal tincture of kaurie gum can be added, and the effect can easily be produced. In sick rooms and in the wards of hospitals such sprays could be arranged to work automatically so as to deliver and diffuse the solution at regular intervals. For this purpose Messrs. Krohne & Sesemann have constructed for me an apparatus which will distribute spray for several hours at a time.

OTHER MODES OF APPLICATION.

The peroxide solution can be prescribed as a gargle, antiseptic and astringent. A good form for this purpose is: Tannin, pure, ten grains; glycerine, pure, one ounce; distilled water, four fluid ounces; diluted hydrochloric acid, ten minims; solution of peroxide of hydrogen, sufficient for eight fluid ounces. To make an eight ounce gargle. An evaporating lotion can be made with the peroxide in the following form: Alcohol, pure (sp. gr. 830), two fluid ounces; anhydrous ether, one fluid ounce; distilled water, four fluid ounces; solution of peroxide of hydrogen (of neutral reaction and ten-volume strength), to twelve fluid ounces. To make a twelve fluid ounce lotion.

Another simple yet useful preparation of the peroxide is as the unguent, for inunction over the surface of the skin after scarlet fever, and other affections where there is free shedding of dead cuticle. The unguent is made by rubbing up ozonic ether with spermaceti ointment, so as to form a thin paste, which may, if desired, be rendered thick by the addition of a little more spermaceti, or thin by addition of olive oil.

ADMINISTRATION BY INJECTION: AN AUTOMATIC INJECTION SYRINGE.

In order to inject the peroxide solution into the cavities or beneath the skin, I have invented a syringe which I call the "automatic syringe," and which Messrs. Krohne & Sesemann have very neatly constructed. It is, as will be seen, a small graduated instrument, having a feeding tube for charging it on one side, and an exit tube for discharging it on the other side. The syringe is automatic in the sense that when both tubes are in place the mere act of working its piston up and down fills it and empties it. The quantities of fluid received and delivered by it vary from ten minims to four fluid drachms, and at the end of the exit tube it can be fitted with injecting needles of different sizes or with a nozzle, according to requirement. With this syringe the peroxide solution can be injected through a needle subcutaneously, as into a carbuncle or into deeper structures. By attaching the delivery end to an enema tube it can be used also for the intestinal injection, and by attaching the same end to a catheter, it can be employed for injecting the bladder. The advantage in every case is that the current can be kept up when once it is started, either for a small or large injection, and that the admission of air is impossible. The syringe might be used without any complication for the transfusion of blood and for aspiration, as well as for transfusion; but it has been specially adapted for the oxygen solution.

CONCLUSION.

In closing these pharmacological notes it is well to recall the important fact that the remedy we have had before us has about it the peculiarity that it is a purely natural remedy, that it is not toxic, and that with the exception of the danger of producing by it gaseous accumulation in the blood, under some circumstances of its use—a danger which admits of being avoided—it is free of all risk. In its remedial application, too, there is no complexity as to its *modus operandi*. In every instance that which it effects is oxidation. For asphyxia it is oxidation; for spasm it is oxidation; for breaking up pus and exudations it is oxidation; for destroying infectious and fetid organic secretions, or excretions, it is oxidation; for producing eliminative action, it is oxidation.

At the close of the paper on peroxide of hydrogen, read before the Medical Society of London in 1860, I said: "Sir, in placing this memoir on the annals of the Society I guard myself, once and for all, from any exaggerated suggestions as to the value of this new medicinal agent. The subject is so novel, even to me after many months' learning and knowledge of it, I have feared to use a sentence that has not been measured and recast over and over again. I am not offering this medicine as an *elixir vitæ*. I do not pretend to know all its properties. I do not bind myself, irrevocably, to that which, at the present meeting, has been offered; on the contrary, I remain open to all new observation and knowledge for correction and guidance. I believe we have here within our grasp a powerful medicine, the full value of which it may take years to develop, and the useful application of which may be developed in directions different from those now advanced. My purpose will be served if I call forth investigation and elicit fact, let the course of the events bend as they may."

A generation has passed since these words, sir, were spoken, and twenty-nine presidents have filled the place you occupy to-night. But to you and my fellow students I re-echo these words; and although I have spoken with more knowledge, experience and confidence in a remedy which forms the most active and preponderating element of the healthy living body, I wish still to express the same earnest hopes with the same candor and the same respectful confidence in the voice of the future.

URINALYSIS.

By D. W. HOUSTON, M.D., Troy, N. Y.

BEFORE prescribing for a patient complaining of loss of flesh, debility, thirst, and increase in micturition, an examination of the urine of the patient is the first important duty of the physician.

There is a method of chemical examination of the urine which gives approximately the percentage of sugar and fulfills all the requirements of a reliable test, which is, I believe, not as generally known as it should be. I refer to the liquor potassæ test, performed in the following manner:

To a quantity of urine in a test tube one-half of its volume of liquor potassæ is added. Then by heating the upper zone of this combination over the flame of a spirit lamp, if sugar be present, a change in color will be soon shown. The color first appearing will be canary yellow, and will indicate, according to its intensity, 1 per cent. of sugar, or less. After further heating, the canary color will be displaced by an amber color, and this will indicate 2 per cent. of sugar. The further addition of heat (if there be sugar enough present) produces a dark Jamaica rum color, and this will show 5 per cent. of sugar; and should, after continuous boiling, the color become dark brown, and the contents of the test tube not transparent, then 10 per cent. of sugar is indicated. Between the four standards of color here given there may be different gradations showing a greater or less percentage of sugar.

When once sugar is detected in the urine of a patient and treatment begun, the convenience of having a reference for comparison with the first or any subsequent testing is highly desirable, in order to determine the progress of the disease and the results of treatment.

The simplicity, beauty, reliability, and accuracy commend this test as the best for the qualitative and quantitative (approximative) examination of sugar in the urine.

The late Professor Ultzmann, of Vienna, depended almost entirely upon this test in his examinations for sugar at the Poliklinik.—*Medical Record.*

CHRISTIA.

THIS is the name of a new impervious dressing recommended as a substitute for gutta-percha tissue. It is prepared from the fibers of manila hemp, and impregnated with a matter unaffected by water, alcohol, chloroform, ether, ammonia, or fats. It has the appearance of a dark gutta-percha tissue, is dark brown in color, transparent, may be folded, bunched, or tied in knots, and can be readily smoothed out again by stroking with the hand. It is, however, not elastic. It does not become sticky, and may be used in any climate.

The "christia" is not only supplied pure and simple, but also impregnated with boric, carbolic, and salicylic acids, iodol, etc.—*Pharm. Zeit.*

COCHINEAL CARMINE.

ANALYSES of this covering are by no means numerous, and that given by Lafar in No. 3 of the current volume of the *Journal für Praktische Chemie* is worth recording here.

The sample was a genuine one, in the form of a loose powder, perfectly soluble in ammonia. The moisture was determined at 110°, whereby the color lost in warmth, and this was not regained by exposure to an atmosphere saturated with moisture. The nitrogenous matter was determined by multiplying the nitrogen by the albuminoid factor.

	Sample. Per cent.	Dry Color. Per cent.
Water	15·50	...
Ash	6·87	8·14*
Nitrogenous matter	23·26	27·60
Coloring matter (by difference)	54·37	64·26

*Containing:

	Per cent.		Per cent.
CuO	0·35	Na_2O	5·40
SnO_2	0·14	K_2O	3·20
Al_2O_3	40·48	P_2O_5	2·71
Fe_2O_3	trace	S_1O_2	0·60
CaO	44·20	CO_2 (by difference)	2·31
MgO	0·61		

The sample contained 0·4 per cent. of sulphur. It will be noted that the ratio of Al_2O_3 to CaO in the ash is very nearly 1 molecule of Al_2O_3 to 2 molecules of CaO. This has also been pointed out by Kopp and by Liebermann, and may no doubt be regarded as evidence of the genuine character of a sample.

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